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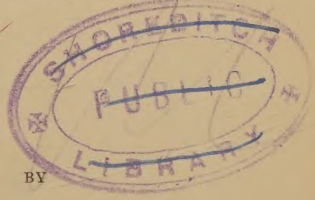
INSECT LIFE

A SHORT ACCOUNT OF THE CLASSIFICATION AND HABITS OF INSECTS



BY

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PREFACE

The object of this volume is to place before those who have little time to study in detail the interesting features of insect life, a condensed account of the more important characteristics of insects, dealing with their economic importance at the same time. The author has aimed at making this short account of interest to the general reader, as well as to those who intend to study this group of invertebrates.

The classification has been simplified as much as possible, and whenever the popular names of the various insects are of general occurrence, they have been made use of in addition to their scientific nomenclature.

As a help to the reader a few woodcuts have been given in the text. Those obtained from other authors are here gratefully acknowledged. Figures 13, 16, 19, 23, 24, 28, 29, 42, 46 and 48 have been obtained from Kirby's 'Text-book of Entomology'. Figures 7, 9, 10, 11 and 12 from Cowan's 'Honey Bee'; 8, 18, 25, 26, 43, 47 and 49 from Clause's 'Text-book of Zoology'; 14, 15, 17, 20, 21, 22, 27, 30, 31, 33, 34 and 35 from Wood's 'British Moths and Beetles'.

FRED. V. THEOBALD.

WYE, KENT.
January, 1896.

CONTENTS

CHAPTER I. Introduction and Classification of Insects. 1

The Animal Kingdom—Arthropods—Insecta—Classification.

CHAPTER II. Metamorphosis of Insects 8

Embryonic Development—Post-Embryonic Development—The Larva—The Pupa—Quiescent Pupæ—Active Pupæ—Complete Metamorphosis—Incomplete Metamorphosis—Changes during and preceding Pupal Life—Comparison of the Alimentary Tract of Larva and Imago—Comparison of Nervous System of Larva and Imago—Emergence of Imago—Conclusion.

CHAPTER III. The Structure of Insects. 25

1. *External Anatomy*—The Head—The Thorax—The Abdomen—Antennæ—Functions of Antennæ—Eyes—Compound Eyes—Simple Eyes—The Mouth—The Wings—The Legs. 2. *Internal Anatomy*—The Alimentary Canal—Digestion—The Nervous System—Respiratory System—Vascular System—Generative System.

CHAPTER IV. Coleoptera or Beetles 46

General Account of Order—Adephaga—Palpicornia—Brachyelytra—Necrophaga—Lamellicornia—Sternoxi—Malacodermata—Teredilia—Heteromera—Rhynchophora—Xylophaga—Longicornia—Eupoda—Pseudotrimera.

CHAPTER V. HYMENOPTERA OR ANTS, BEES, AND WASPS . 78

General Account—Hymenoptera-terebrantia—Saw-flies—Corn Saw-fly—Turnip Saw-fly—Gooseberry Saw-fly—Pine Saw-fly—Wood Wasps (Sirices)—Gall Insects—Ichneumon Flies—Hymenoptera-aculeata — Ants — Fossorial Hymenoptera — Diploptera (Wasps)—Anthophila (Bees).

CHAPTER VI. LEPIDOPTERA OR BUTTERFLIES AND MOTHS . 100

General Characters—Larvæ—Pupæ—Scales and Coloration—Rhopalocera—The Cabbage Whites (Pieridæ)—Heterocera—Sphinges — Bombyces —Noctuæ— Geometræ—Currant Moth—Winter Moth—Pyrales—Crambi—Tortrices—The Codlin Moth—The Tineæ—The Diamond-back Moth—Pterophori and Alucitæ.

CHAPTER VII. DIPTERA OR TWO-WINGED FLIES 141

General Account—(1) *Nematocera*—Fleas—Gall Gnats—Wheat Midge—Hessian-fly—Culicidæ or Gnats—Tipulidæ or Crane-flies—The Fever-fly—(2) *Brachycera*—Tabanidæ or Gad-flies—*Proboscidea*—Syrphidæ or Hover-flies—Eristalidæ—Oestridæ or Warble-flies — Muscidæ — Anthomyidæ — Cabbage-flies — Onion-fly — Carrot-fly — Celery-fly — Frit-fly — Gout-fly — *Eproboscidea*.

CHAPTER VIII. HEMIPTERA OR BUGS AND APHIDES . . 174

General Account—*Homoptera*—Cicadidæ—Fulgoridæ—The Hop Frog-fly—Plant-Lice or Aphides—American Blight—Snow-flies (Aleyrodidæ)—Scale Insects (Coccidae)—The Mussel Scale — *Heteroptera* — Scutelleridæ — Lygeidæ — Cimicidæ — Reduviidæ—Gerridæ—Nepidæ—*Anoplura*—Lice.

CHAPTER IX. ORTHOPTERA OR GRASSHOPPERS, COCKROACHES, ETC. 191

General Account—Cursoria (Earwigs and Cockroaches)—Gressoria (Praying and Stick Insects)—Saltatoria (Crickets, Grasshoppers and Locusts).

CHAPTER X. Neuroptera or Dragon-flies, Ant-lions etc. 199
General Account—Neuroptera vera—Pseudo-neuroptera—Thrips—Mallophaga or Bird Lice—Thysanura—Collembola.

APPENDIX I. Insecticides 214
Object of Destroying Insects—Paraffin—Quassia—Soft-soap washes—London Purple and Paris Green—Gas Lime—Sulphur and Tobacco—Soot—Special Mixtures—Painting Trees—Instruments.

APPENDIX II. List of the more important Works and Monographs on special Groups of Insects. 225

INDEX 229

INSECT LIFE

CHAPTER I

INTRODUCTION AND CLASSIFICATION OF INSECTS

The Animal Kingdom—Arthropods—Insecta—Classification.

A CASUAL glance at natural objects shows they can be divided into two great divisions, the inanimate and the animate. The former being rocks and minerals, the latter animals and plants.

As animate nature is divided into two primary groups called Kingdoms, so are these two Kingdoms, the Animal and the Vegetable, each divided again into smaller and smaller groups. The *Animal Kingdom* being composed of two sub-kingdoms, called the Vertebrata and the Invertebrata; the former being animals with an internal skeleton, the latter with no internal skeleton. Each of these sub-kingdoms is again composed of smaller congregations of life, called *classes*. Whilst each class is composed of *orders*, which are groups of *genera*. The final point being the *species* which constitute the genera.

Now amongst the Invertebrata we shall find a large group of animals, massed together under the name of ARTHROPODA.

This division which is one of the most important in the invertebrate sub-kingdom, contains a vast assemblage of forms of very diverse appearance and habits. The most important features of the Arthropoda and by which they

are distinguished from the other invertebrate classes (Protozoa, Vermes, Mollusca, etc.) are briefly as follows:— The body is composed of a number of rings, segments or somites, arranged along a longitudinal axis. Each segment may have a pair of appendages (some always have). The appendages are always composed of joints and are united to the body by a distinct articulation; they are always hollow and contain prolongations of the muscles. The segmented body and the articulate limbs are more or less completely covered by a thick chitinous coat, or exoskeleton. The nervous system is composed of a double chain of ganglia united by commissures, and anteriorly perforated by the œsophagus. The nervous system is placed always on the ventral surface of the body. Respiration takes place by means of gills, pulmonary sacs, or by specially developed tubes, called tracheæ. The hæmal system when developed is present on the dorsal surface and consists of a large tubular heart, opening on each side by valvular apertures into the perivisceral spaces containing corpusculated blood.

Classification of Arthropods.

These jointed-limbed creatures or Arthropods are divided into four groups, viz., the CRUSTACEA or Crabs, Lobsters, Shrimps, etc., the ARACHNIDA or Spiders and Scorpions, the MYRIAPODA or Centipedes and Millepedes, and the INSECTA or true insects.

The following are the characters by which these four classes of Articulate animals can be distinguished:—

1. *Crustacea.* This class may roughly be defined as the water breathing Arthropods, respiration taking place by means of branchiæ or gills. The head is also always furnished with two pairs of antennæ. The abdomen

carries locomotary appendages. Compound eyes are present.

2. *Arachnida.* Respiration takes places by means of lungs, tracheæ, or by the whole body surface. Head and thorax united into one piece, the cephalo-thorax; in some cases this is also fused with the abdomen. Antennæ are never developed (as such). The abdomen never carries locomotary appendages. The number of legs always eight. Simple eyes only present.

3. *Myriapoda.* Respiration by tracheæ. Head distinct from body. One pair of antennæ. No clear mark of distinction between thorax and abdomen. Abdomen composed of many segments. Legs numerous, always more than eight pairs.

4. *Insecta.* Respiration by tracheæ. Head, thorax and abdomen always distinct. One pair of antennæ. Eyes simple and compound. Legs always six in number. No abdominal locomotary appendages. Two pairs of wings generally present (Fig. 5).

Such, briefly, are the distinguishing marks of the four divisions of Arthropods. The last, or the Insecta, is the one that we have to deal with in this work and to which the following pages are devoted.

Insecta.

The *Insecta* contain a very large number of forms; some 2,000,000 species are said to be living in the world by Dr. Sharp.* No matter whether we go into the Arctic Circle or into the Tropics, insect life manifests itself; in dark caves as well as in the brilliant sunshine; in water and on land. Every one of the countless species of plants and trees has some insect living upon

* The total number described, however, is under 250,000.

its tissue; most insects exclusively feeding upon one particular genus of plants. There are also a large number of species that live as parasites, not only upon other animals and man but upon members of their own class. A third group live upon decaying matter. Although, as mentioned above, insects are found in the ice-bound coasts of the Arctic Circle, they nevertheless are few, especially in species. It is a well-known fact that as we approach the warmer parts of the earth, not only the flowers and the birds, but the insects also become more abundant, more brilliant and larger. Think of the insignificant gnats and midges in the Arctic regions, the dingy butterflies of England, the gorgeous and brilliant papilios of Brazil and Africa. Besides being more beautifully coloured, insect life is more abundant in the warmer regions of the globe, not only in species but in individuals; for instance, the armies of locusts that carry all before them, the vast clouds of mosquitoes and May flies seen over the African Lakes. Although it is chiefly, then, in the warmer parts of the world that we find insect life abundant in all its varied forms, nevertheless the 13,000 British species offer a vast field for our research and study.

The relation of insects to flowers is one of great importance, insects to a very large extent acting as the mediators in the necessary fertilization of the flowering plants. Not only is this group of use in the above way, but by their aid land is fertilized; decaying and putrefying matter carried away, as seen in the work of the Blow Fly and the Burying Beetle. There is no doubt, as Drummond says, that the Termites or White Ants act as fertilizers and disintegrators of the soil in Africa, in the same way that the worms, as Darwin has shown, act here. There are yet other ways in which the insects are of service to us. Honey, cochineal, ink, sealing wax, etc., are the product of

insects. In the Roman age they even formed a recherché dish for the gourmond, the 'Cossus' larvæ being no unusual item on the menu,* and even at the present time we hear of the Africans compressing gnats and May flies into cakes for food and drying them in the sun, whilst the Palm Weevils are highly valued all over the West Indies.

At the present day we are taught not to consider the useful insects, but those that do us injury. It has become a well-established fact that insects do a vast amount of damage to the crops. We are told an acre of wheat should normally produce 80 bushels of corn, when the soil is in a perfect condition. But no such thing is ever heard of, 32—64 at the most is all that can be expected, even in the virgin soils of America. To the insects and fungi is chiefly attributed this persistent loss. The question may be asked, How is it that we have injurious insects? The answer is that man by altering the natural state of the land, by draining, cultivation, destruction of weeds, trees, etc., has disturbed the balance of nature. One kind of insect has been given undue advantages over the others and so increases rapidly and destroys in large quantity the vegetation upon which it lives. But if left alone Nature will eventually restore the balance, some parasite will spring up and sweep off the devastator. But Nature works slowly. There are times when man also can help to restore this equilibrium, which he has upset by his works.

Classification.

The following are the orders into which the insects are now usually divided†:—

* These were probably the larvæ of some large wood beetle.

† Considerable difference of opinion still exists as to the exact classification of insects, the above is, however, the simplest and most rational method.

ORDER 1. *Coleoptera.* The mouth masticatory, furnished with an upper lip, two mandibles, two maxillæ with 4-jointed palpi and a lower lip. Four wings are present as a rule, the front pair generally being hardened by a thick deposit of chitin (*Elytra*), and folding over the membranous posterior pair, forming a kind of case for their protection.

ORDER 2. *Hymenoptera.* The mouth is furnished with mandibles and likewise a proboscis, formed of maxillæ and labrum. Four wings generally, all membranous; few nervures. The female armed with an ovipositor at the end of the abdomen, sometimes converted into a sting.

ORDER 3. *Lepidoptera.* The mouth formed into a long, coiled, sucking tube, formed of greatly elongated maxillæ, protected when at rest by the hairy labial palpi. Labrum and mandibles rudimentary; maxillary palpi small. Wings four, membranous, covered with hairs and scales; nerves few, mostly longitudinal.

ORDER 4. *Diptera.* Mouth suctorial. Front pair of wings alone present; posterior pair reduced to two club-shaped processes called halteres. Anterior pair may be absent as well (Fleas, etc). Veins few.

ORDER 5. *Hemiptera.* Mouth suctorial, beak shaped, made up of a jointed rostrum, composed of an elongated labium, which forms a jointed, tubular sheath for the needle shaped maxillæ and mandibles. Wings four, membranous, naked; may be wanting.

1. *Heteroptera.* Front wings horny at the base; antennæ long; head free from thorax.

2. *Homoptera.* All wings membranous or wanting; antennæ short: head united closely to the thorax.

ORDER 6. *Orthoptera.* Mouth masticatory. Wings four; front wings usually smaller than posterior ones, leathery. Posterior pair membranous and folded like a fan. Nerves

numerous, the spaces between filled with many transverse reticulations.

ORDER 7. *Neuroptera.* Mouth furnished with mandibles. Wings four, all membranous, nearly equal in size, traversed by numerous veins having a longitudinal and transverse direction, giving the wings a lace-like appearance. Female may have a conspicuous ovipositor, never a sting.

The reduction here to seven orders will greatly facilitate the study of classification. There are absolutely no grounds for raising the *Stylops* and the *Fleas* to orders of their own. The former is a true beetle and the latter a true fly. The orders Thysanura, Collembola and others of the so-called Ametabola are now merged into the more definitely defined groups, whilst the separation of Neuroptera and Pseudo-Neuroptera cannot be sanctioned on palæontological grounds. Our object should be to have as simple and rational a classification as we can and not to complicate matters by forming orders upon doubtful characters.

CHAPTER II

METAMORPHOSIS OF INSECTS

Embryonic Development—Post Embryonic Development—The Larva—The Pupa—Quiescent Pupæ—Active Pupæ—Complete Metamorphosis—Incomplete metamorphosis—Changes during and preceding Pupal Life—Comparison of Alimentary Tract of Larva and Imago—Comparison of Nervous System of Larva and Imago—Emergence of the Perfect Insect—Conclusion.

A BUTTERFLY does not hatch a butterfly from the egg, nor a bee a perfect bee. All insects go through certain stages during their lifetime, although, as we shall see, certain groups undergo very slight alteration during their growing period. Insects may be said to hatch from their egg in an undeveloped state.

The post-embryonic changes, the larva or caterpillar, and the pupa or chrysalis constitute the *metamorphosis of Insects.*

Embryonic Development.

The *eggs* of insects are very varied in shape, colour and markings, some are beautifully sculptured structures, others are of curious form; the majority are oval or round bodies of small size, except in some of the largest moths.

The segmentation of the insect egg has not been fully studied, but the changes following this have been ably worked out by Kowalevsky. At the close of the segmentation of the ovum we find a uniform layer of cells (*the blastoderm*)

enclosing the central mass of yolk. On the ventral surface of the egg these cells form a thickening, which becomes the *ventral plate* (Fig. 1*a*). A furrow, the *germinal* groove, shortly appears at the posterior end of this plate (*c*). The

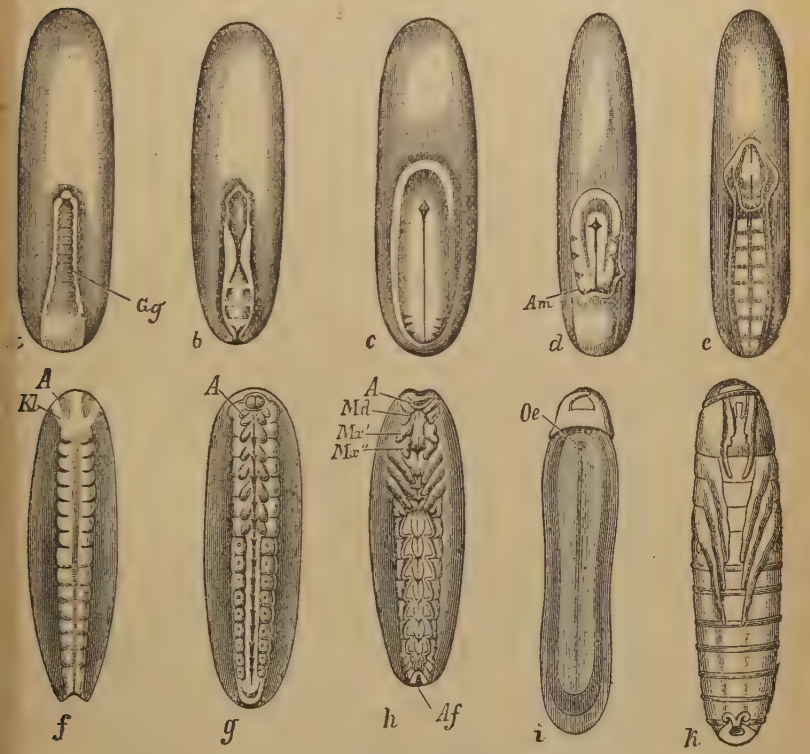

Fig. 1. Embryos of *H. Piceus* viewed from ventral surface. (After Kowalevsky).

sides of the furrow grow and eventually convert it into a canal, which becomes solid. The long columnar cells of its walls divide and give rise to another layer of cells, the

mesoblast. Whilst these changes have been going on certain embryonic membranes have appeared, strongly resembling in their formation the true and false amnion of vertebrate animals. They appear as a double fold of the blastoderm round the border of the germinal area. The inner side of this fold is called the 'amnion' (*am*) and the outer the 'serous envelope'. The yolk is able to pass between these two membranes and does so in certain parts.

During the above changes the ventral plate has considerably grown, so as to cover a large part of the egg. At the same time the ventral plate becomes marked by transverse lines, which never exceed seventeen, and two swellings or lobes appear in front, the *Procephalic lobes* (*kl*).

From this ventral plate the entire body of the embryo is formed.

Shortly after the segments have become marked off, small rudimentary processes, the appendages, arise, the eight pairs becoming visible about the same time (*g*).

On the procephalic lobes are placed the rudimentary antennæ (*A*) and the remaining appendages on the following segments. The eighth pair, the ones behind the six future legs, very soon become entirely lost.

The nervous system becomes marked off as a pair of epiblastic thickenings on each side of the middle line. A proctodæum is formed at the hind end of the body, somewhat later than the stomodæum at the anterior end, as two invaginations.

After these stages have been passed the yolk becomes split up into spheres and a sack gradually forms around the yolk. The two membranes, the amnion and the serous membrane, then rupture and almost disappear. The proctodæum becomes the rectum and malpighian bodies, and the stomodæum the œsophagus and proventriculus; both eventually uniting with the mesenteron to form the ali-

mentary canal. The superficial layer of the blastoderm becomes the *ectoderm*, the inner layer is the *mesoblast*, which soon becomes divided into two lateral bands. The origin of the third layer, the *hypoblast*, is not clearly understood.

The tracheæ and salivary glands arise as independent, segmentally arranged epiblastic invaginations. In the embryo we find stigmatic openings in all the thoracic and abdominal segments, except the last two, whereas in the adult we never find them between the prothorax and the head. In the *Collembola*, however, Lubbock has shown that only two stigmata are present and these are placed on the head.

Post Embryonic Development (Metamorphosis)

The egg which has undergone the changes described above, eventually gives rise to a living creature, which is usually termed, a *larva* (Fig. 2), *caterpillar*, *maggot* or *grub*, totally distinct in most insects from the perfect state of the species.

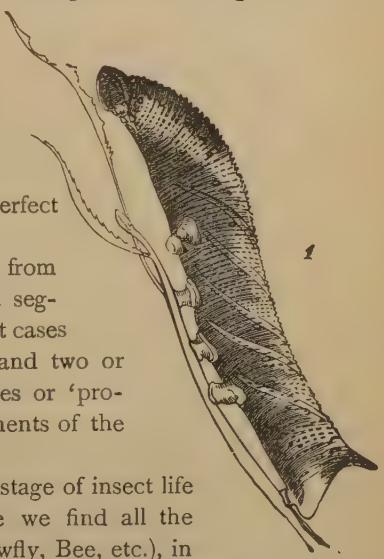

Fig. 2. Larva of Eyed-Hawk Moth.

The *larva* on hatching from the ovum has usually a segmented body and in most cases six horny legs in front and two or more fleshy protuberances or 'prolegs' on the hinder segments of the body.

This second or larval stage of insect life is very varied, in some we find all the legs entirely absent (Blowfly, Bee, etc.), in others fully developed (Butterfly, Sawfly). The larval stage of many insects have hard

and biting mouths, others having them very slightly formed.

Amongst the butterflies and moths the caterpillars have as a rule the six true legs of the insect and ten fleshy prolegs; in the Sawflies we find the legs as many as twenty-two, there being eight pairs of prolegs.

Those insects that live an aquatic life have usually their larval stage, not only with the six legs well developed, but also with other curious appendages, such as branchiæ or gills, present upon their surface. During the larval stage of insect life the individuals are always active and spend most of their time in feeding. The larval stage is really the growing period of the insect.

Moulting.

This continual feeding, resulting in the gradual and somewhat rapid growth of the larva, causes an abnormal pressure on the integuments of the animal. In time the skin becomes too small to hold the contents of the body. This pressure causes a rupture of the skin. Prior to this a fresh integument has formed beneath the old one, and on the bursting of the old skin, the caterpillar crawls out from its former covering with the fresh one ready formed. During this process of 'moulting' not only does the soft skin of the body become shed, but the horny head covering also becomes cast off, in the same way that a lobster 'casts' its shell and a snake 'sloughs' its skin.

This moulting which is common to many of the arthropods (Crustacea, Insecta, etc.), in the true insects takes place only during the second, or larval, stage of their life.

The Skin.

The *skin* of the larva is made up of two layers, an inner and an outer. The deep lying skin is the true

skin and contains no chitin. The superficial layer contains the pigments which give the caterpillars of Butterflies and Moths their often beautiful colours and also contains depositions of fats and calcareous salts. This superficial layer is the true epidermis or scarf skin, and is the only one shed in the process of moulting. Both these layers are closely connected, and ducts passing from glands in the inner layer penetrate the epidermis. In the larval state this epidermis is made up of very simple cells; in the imago the most beautiful cells and hairs can be seen to be modified epidermal cells, derived from the simpler cells of the larval epidermis.

The larval body can be divided into three divisions, (1) the *head*, which is hard and horny and armed with sharp biting jaws in most vegetable feeders, but often reduced to a pair of simple hooks in parasites (*Oestrus*), (2) the *thoracic region*, composed of three segments, to which the six horny legs are attached. In the larvæ of Flies and Bees, these legs are absent, and we have to assume that the three first segments form the thoracic region. (3) The *abdominal region*, composed of nine to twelve or more segments and not furnished with true legs, but often with fleshy sucker feet or prolegs.

This larval stage of insects takes place in very diverse positions. The majority of larvæ feed upon vegetable tissue and are found devouring the root (Chafers), stem, (Cossus, Sirex) and leafage (caterpillars of Butterflies, Sawflies, etc.) of trees, shrubs, and plants.

Those that live upon leafage work in two ways, viz., by burrowing between the tissues of the leaf, miners as they are called, (*Haltica*, *Tinea*) and by devouring the whole tissue of the leaf. The larvæ of many flies live as parasites (*Oestrus*, *Sarcophagus*) within and upon the body of other animals and cause great pain and disease ('False-Staggers,'

Warbles, etc.). Others feed upon excreta and decaying matter. Those feeding upon excreta (Bibio, Musca, etc.), are termed *saprophytes*. The 'blow fly' (*Musca vomitoria*) may be taken as an example of those living upon decaying animal matter. These larvæ or insect scavengers, as they are often called, do an immense amount of good in helping the hasty decay of putrescent matter. Stores are also subject to the ravages of insects in their larval state (*Calandra*, *Meal Worm*, *etc.*). Carnivorous habits are also developed in the larval insect, many feeding upon other forms of life, and this is particularly prevalent in aquatic forms (*Aeschna*) belonging to the Neuropterous order of insects, and in the larva of the Ant Lion (*Myrmeleon*) which forms a pit into which other insects fall, ready to be devoured by the larval Ant Lion below.

All these larvæ of various habits and forms change their skins a definite number of times and eventually reach their full size. Then, the skin on splitting gives rise, not to the larva or grub again, but generally to a totally distinct creature, a chrysalis, pupa, or nymph.

The Pupal Stage.

The pupal stage, or third stage, in the life of an insect is generally passed as a period of rest, the pupa being quiescent and taking no food. It is the period when the caterpillar is being transformed into the beautiful butterfly, the sluggish maggot into the busy bee. Prior to the larva undergoing its last moult, it passes a period of rest, when the tissues of the body become disturbed and the chrysalis case is forming beneath its skin. In some insects (Moths, Sawflies, etc.) the larvæ preparatory to this change spin, by means of a silken thread derived from the salivary glands, a case or covering in which the pupal

stage is passed. This case is called a *cocoon* and may be typically seen in the cocoon of the Silkworm. Sometimes these silken cases reach an immense size, the author having one of the Atlas moth (*Attacus Atlas*) seven inches in length.

In the case of Butterflies, this cocoon may be reduced to a simple band of silk (*Papilio*) and a small attachment at the tail end.

The form of the pupa or chrysalis (Fig. 3. B) is varied, but not to the same extent as the larval stage that precedes it.

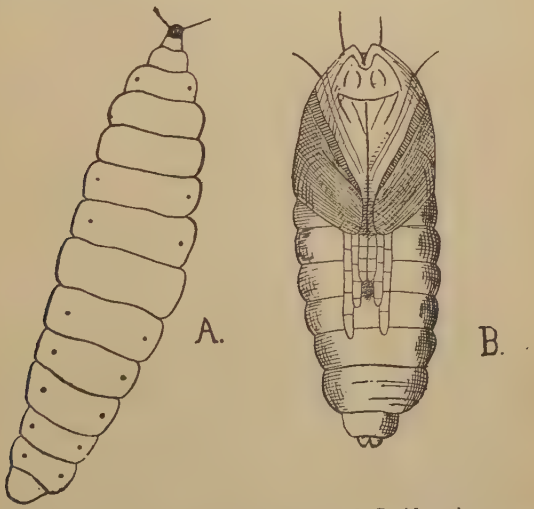

Fig. 3. Larva (A) and Pupa (B) of *Cecidomyia*.

Upon the surface of the thick integument, hardened by deposition of chitin, the future limbs, wings, eyes, and antennæ are marked in a clear outline. There are no traces of wings in the caterpillar, but that they are being formed in the quiescent pupa can readily be seen on examining any kind of chrysalis.

The wing cases are bent under the ventral surface of the thoracic region of the pupa and from the head bend down between them the pair of antennæ and between these are present the six legs folded closely together. The segments in the abdomen are soft between one another and cause the pupa to become very flexible. The segments are often fewer than in the larva and the whole integument, except the spaces between the body segments, becomes hardened. It will also be noticed that the thoracic region has become more fully developed, especially the second and third segments, the meso- and meta-thorax, to which not only the legs, but the wings are attached. In the chrysalis the three thoracic segments, which were separate in the larva, have become united into one piece. These old divisions can often be plainly seen by lines or sutures. The first or prothorax usually becomes smaller and the others larger. The pupæ of the various insects may be divided into two groups:—viz.,

A. Quiescent pupæ. B. Active pupæ.

Quiescent Pupæ.

The typical (complete) metamorphosis of an insect contains the active larva, the inactive pupa, and the active imago. But we shall see later that there is what is known as an incomplete metamorphosis, where the difference between these stages is very slight.

The quiescent pupæ are typical of the complete metamorphosis. They are either found in a cocoon, or naked under the ground, or amongst leaves and moss. Some few larvæ change to the pupal state in the trees where they have been living (*Cossus*). This group of chrysalids remain where they were originally produced, until the time approaches for the shell to burst and the perfect

insect to fly away. Shortly before this takes place the sedentary creatures commence active and vigorous movements, and in the case of those present in tunnels, in wood, and deep in the earth, they gradually work their way to the surface, by means of spines and bristles on the segments. This is well shewn in the curious empty brown cases seen sticking half out of the grass in autumn, the pupæ cases of the Daddy-Long-Legs (*Tipula*).

Active Pupæ.

Certain insects in their pupal stage are always active, although they present great differences to the adult form (*Culex*, *Chironomus*, *etc.*). These active pupæ are mostly aquatic and are armed with curious breathing apparatus. The 'gnats' (*Culex*) in the pupal stage are extremely active, and if watched the curious nymphs are seen to rise every now and then to the surface of the water and project two horns, present on the head, above the surface—by this means air is taken in.

But there are active pupæ very different to these. The active nymphs of the gnat are very unlike the imago. In the true active pupæ, the pupal stage nearly approaches the adult, in many cases colour only distinguishing them, or the rudimentary wings. The legs, however, are free (*Aphides*, *Libellula*, *etc.*). The insects having this kind of pupal stage are said to undergo an 'incomplete metamorphosis', in distinction to the 'complete metamorphosis' of such kinds as the butterfly and gnat.

Complete Metamorphosis.

The changes during the life of an insect undergoing a complete metamorphosis are very marked and well defined.

There is always a quiescent period, that is, a period of time when feeding does not take place. In most cases this quiescent period is marked by the complete cessation of motion, but, as we see in the gnat nymphs, activity may still remain. In all the pupæ, however, the legs are only roughly marked out on the pupal case and are in no wise used for locomotion. The first or larval stage is also always very different to the perfect insect. There is no resemblance at all between the caterpillar of the butterfly, the maggot of a bee, and the butterfly and bee themselves. In 'complete metamorphosis', then, the stages are well defined; *i.e.* the larva and pupa do not resemble one another, nor do either resemble the perfect creature that springs from them.

The *Lepidoptera* (Butterflies and Moths) the *Diptera* (Flies) the *Coleoptera* (Beetles), the *Hymenoptera* (Ants, Bees, and Wasps) are typical orders that undergo this complete form of change.

Incomplete Metamorphosis.

The incomplete transformation is well seen in Aphides or Plant Lice. The difference between the larval Aphides and pupal Aphides is very slight; colour and the presence of rudimentary wings are alone features by which we can distinguish one stage from another. In this incomplete transformation the pupal* stage is always active and the legs are free. There is often very little difference to the imagines. Some of the best examples may be seen in the Plant Lice, the Dragon Flies and Cockroaches.

The *Hemiptera* (Bugs, Aphides, etc.), the *Orthoptera* (Grasshoppers, etc.) and some of the *Neuroptera* (Dragon Flies, Ant Lions) exhibit these incomplete changes. Too

* The *Coccidae* or Scales are sedentary, but this is a secondary habit.

much importance must not be attached to these features in classification, as we get insects closely related that undergo complete and incomplete metamorphosis.

The Changes During and Preceding Pupal Life.

In the case of those insects that undergo an incomplete metamorphosis the changes from the larva to imago are gradual and unimportant. The wings increase as epidermal folds gradually, that is at each moult. In the *Ephemeridæ* or May Flies the external branchial appendages of the larva become cast off on reaching the mature state.

Very different are the changes which take place in '*holometabolic insects*'.* The larvæ having a very different mode of life to the adults. So different are their modes of life that a transitional form between the leaf-eating caterpillar and the sucking butterfly could not exist. These changes take place during the quiescent or pupal state. Many of the external organs are formed prior to the pupal state but do not make their appearance until it is reached.

One of the simplest changes is seen in a small two winged fly studied by Weismann, *Corethra plumicornis*. The larva of this species has no thoracic appendages, but prior to the last moult certain structures formed of invaginated epidermis, called *imaginal discs* are formed. These imaginal discs are 12 in number; 6 dorsal and 6 ventral. From the lower ones the legs are formed, arising as spiral outgrowths, and from the two posterior dorsal ones the wings arise. The pupal stage is short and the changes taking place in it very insignificant. But in Butterflies and Moths, although the wings, etc., spring from the imaginal

* Insects with complete metamorphosis are called *holometabola*, those with incomplete *heterometabola*.

discs formed in the larvæ, the changes are much more important; the whole nervous and muscular systems and alimentary canal become altered, as is described later. In the *Muscidae* (Houseflies, Blowflies, etc.) the changes are far more complicated, the abdomen of the maggot becomes *in toto* the abdomen of the fly, but the thorax and head are entirely reformed during the pupal stage. During the embryonic life of the maggot, imaginal discs become formed and continue to grow during larval life. During the pupal period they grow more rapidly, unite together and form a continuous new epidermis from which appendages grow out. The front epidermis of the larva then has no share in the epidermis of the anterior parts of the adult. These discs in *Musca* are eight in number, one pair of cephalic and 3 pairs of thoracic, each pair giving rise to one of the thoracic rings. Much more remarkable are the internal changes. There seems to be a total or partial disruption of all the internal organs, except those of generative function. The anterior part of the alimentary canal, the muscles and nerves (peripheral) become entirely disrupted. The rest of the digestive tract, Malpighian vessels, heart and central nervous system become partially broken up. The cells which form these various parts apparently undergo a fatty degeneration, the nuclei of the cells alone remaining in many cases. The plasma resulting from this breaking up of the various larval organs retains roughly the form of the organs and becomes again built up into similar structures, those of the imago, but often very different from the larval ones.

Comparison of Alimentary Tract of Larva and Imago.

To fully understand the complicated nature of the changes that take place during pupal life described briefly

in this chapter, we had best consider the more important differences between the internal organs of the larva and imago. Fig. 4 shews the organs in the silkworm. In the silkworm or caterpillar stage the œsophagus is short; the stomach forming a very long cylinder and constituting the greater part of the alimentary canal. The intestine is very small. Now on examining the canal of the silkmoth we shall see a long narrow œsophagus, with a large swollen sac, the crop; the stomach being small, whilst the intestine has become long and coiled, with a swollen portion at the ventral end. There is a great difference between these two alimentary canals. One (the worm) being adapted for herbivorous life, the other (the moth) for sucking the nectar from flowers; the change from one to the other taking place during the pupal stage, when the canal of the silkworm becomes broken down into the mass of cells, and reformed. This process is called *histolysis* by Weismann.

Fig. 4. Alimentary Canal of Larva. Silkworm.

Comparison of Nervous System of Larva and Imago.

The changes that take place in the nervous system are even more marked, but much simpler to understand, the nervous system simply concentrating in certain parts of the body. These changes in the nervous system, according to Newport, take place sooner than those of the alimentary canal. The typical nervous system of a larva (the bee), consists of a double chain of nervous tissue lying on the ventral side and passing along beneath the alimentary canal, eventually

bending around the œsophagus and passing on to the head. In each segment this nervous chain is swollen into two large nervous masses called ganglia. The largest is in the head and over the gullet, and is called the brain. The ganglia which form the brain in the moth are seen to be small in the larva; during the pupal stage they increase in size, and in the imago they fill up nearly the whole cavity. These cerebral ganglia become united so as to form a bi-lobed mass.

On looking at the nervous system of the perfect insect, the bee, we find a very different arrangement. Instead of the three distinct thoracic ganglia, we find that the second and third have become one and that the first is much larger than in the maggot-state. There is also considerable concentration in the abdomen. The ten abdominal ganglia of the maggot, in the adult are reduced to five. During the pupal state the first and second abdominal ganglia unite, according to Brandt, with the second and third thoracics. The last three but one stomach ganglia also unite, but in the larval state others coalesce so that by the time the bee has hatched from the pupa, the ganglia instead of numbering seventeen, number nine. The brain in the larva is composed of a large mass at the top, supra-œsophageal ganglia and three small ones beneath; the latter soon unite into one, the sub-œsophageal. This concentration of the nervous system which appears to be taking place during the whole insect life, becomes, as is seen, much more rapid in the chrysalis stage. The whole central nervous system of the larva becomes partially broken down in the chrysalis, while the peripheral nerves are totally destroyed and reformed. They undergo what Weismann calls *histolysis*. This redistribution and concentration are due first of all to the altered conditions under which the adult lives, and to the smaller number of segments in the adult body than in the maggot. Concentration

of the ganglia, then, is the result of concentration in the segments.

The Emergence of the Perfect Insect.

The insect, then, becomes transformed from the larva or grub into the perfect creature during the quiescent or pupal stage. If a chrysalis is opened a short time prior to the emergence of the insect, the perfect creature will be found closely wrapped around by the hard integument. The bursting of the pupal case takes place at all times of the day and night. The imprisoned insect when ready to emerge moves violently about and breaks the case in which it is confined, either over the thorax or more often beneath, where the legs, etc., are marked out by sutures. On the shell splitting, first one, then another leg is forced out and by degrees the insect frees itself from the shell. As soon as free it crawls to some suitable place and remains stationary until it has become mature.

There is a popular idea that a small moth grows into a large moth; a small fly into a large fly. Such is never the case. No insect grows after it is once hatched from the pupal case. The maggot or larval state grows and sometimes the pupa in incomplete forms, but never the fully formed creature. Certain appendages, the wings, grow after hatching, and that is all.

The imago is bathed in a fluid within the pupal case, and this is the cause of the wet appearance on hatching.

The moth at once commences to dry, and at the same time the wings grow larger and larger until the full size is reached and then they are hardened by the air. The growth of the wings is very rapid; an insect hatched in the morning may be flying about in a few hours or even sooner in warm weather.

Conclusion.

The stages, then, through which insects pass on hatching from the egg are three in number, the *larva, the pupa* and the *imago.* The larval stage is the stage of growth in all, and in those that undergo a complete metamorphosis, it is the only period of post embryonic growth. In the insects undergoing the incomplete transformation growth *may* take place in the pupal stage as well. Having completed the growing period, during which repeated moultings or castings of the skin have taken place, the insect enters a period of rest where the organs become re-formed, some wholly and others only partially. The carnivorous or herbivorous organs are metamorphosed into the sucking organs used by the perfect insect.

The perfect insect is, then, formed from the organs and parts of the larva during the pupal or chrysalis state. When all is ready the hard case of the nymph bursts and the perfect insect emerges and soon is ready to fly about and pass its time in feeding and continuing its species. Such, briefly, is the metamorphosis and the changes connected with it, through which the insects pass during their life.

CHAPTER III

THE STRUCTURE OF INSECTS

1. *External Anatomy*—The Head—The Thorax—The Abdomen—Antennæ—Functions of Antennæ—Eyes—Compound Eyes—Simple Eyes—The Mouth—The Wings—The Legs.

2. *Internal Anatomy*—The Alimentary Canal—Digestion—Nervous System—Respiratory System—Vascular System—Generative System.

THE structure of insects may be discussed under two separate heads, (1) the *External structure*, (2) the *Internal structure*.

The classification of insects depends upon the various structural peculiarities of the various groups, chiefly upon the external structures, and it is necessary to have a clear understanding of the plan upon which the insect body is built, before proceeding to the account of the various orders of insects and their classification.

1. External Anatomy.

A typical insect's body, such as a grasshopper, is divided into three parts, the *head* (*A*), the *thorax* or middle body (*B*), and the *abdomen* or hind body (*C*). Fig. 5.

The two former have upon them various organs or appendages, while the latter is always destitute of appendages, but contains at the extremity the external sexual organs (*k*).

The Head.

The head of insects is theoretically composed of a number of segments closely united. It bears upon its ventral surface the mouth, which is armed or composed of very varied parts, useful to us in classification, as well as to the insect in feeding. The head also has upon it two compound eyes (*b*) which are placed on each side, and in many insects one to three simple eyes or ocelli are present as well.

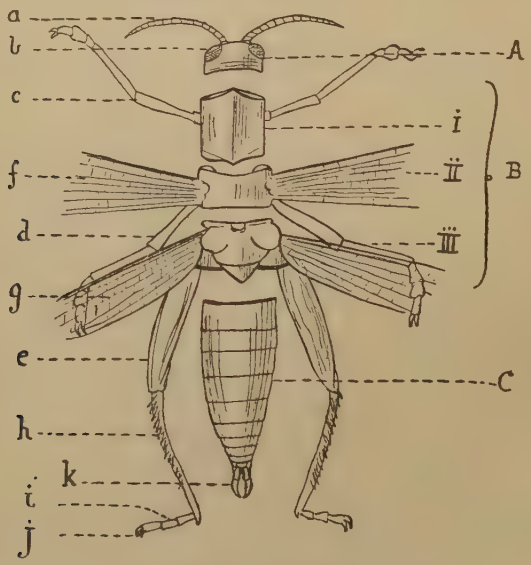

Fig. 5. Structure of a Typical Insect.

Besides these sensory organs, two other processes, the *antennae* feelers or horns (*a*) are also present in all insects. The head in extremely variable in size and shape in the different groups of insects, some, as the bee, being triangular, some oval, others rounded.

The head as seen in the bee, and we can take this as typical of all insects, consists of the *vertex* or crown; below this the face, the *genae* or cheeks, and the *clypeus* or nose. We find the ocelli present upon the vertex or crown, on the summit; the antennæ attached to the lower part or face, just above the clypeus. There is also often present a ridge down the face between the eyes, called the *carina*. The head is attached at its posterior concave surface to the mid-body or thorax, sometimes closely united (*Beetles*), sometimes by a thin neck (*Ants*).

The Thorax.

The *Thorax* (*B*) is composed of three segments known as the *pro-*, *meso-*, and *metathoracic* segments. The prothorax is the part united to the head and is very often reduced to a mere collar (*B*i). It bears the front or anterior pair of legs. The second segment or *mesothorax* (ii) joins the prothorax in front and carries dorsally a pair of wings and ventrally a pair of legs. This second thoracic region is always well developed and large in flying insects. The extra attachment of muscles of flight being the cause of this increase. The third segment or *metathorax* (iii) also carries a pair of wings dorsally and a pair of legs ventrally. It is usually well developed for the attachment of the leg and wing muscles, but not to such an extent as the mesothorax. This great development of the second and third thoracic regions does not take place until after chrysalis life has progressed.

A typical thorax can be seen best in the flea (*Pulex*). In Pulex (Fig. 38) all three segments are separate, but in most insects the thorax has become fused together and the segments are only seen by the sutures or lines, marking off the old separations. In the flea we shall observe that the

thoracic segments are each composed of two pieces, a dorsal and a ventral piece.

The dorsum of the thorax when the segments are united is marked off by ridges and grooves into four parts, known as the *pre-scutum*, the *scutum*, the *scutellum* and the *post-scutellum*. The pre-scutum is very small and often remains as a membranous piece. The scutum which supports the wings is larger. The scutellum can be seen well between the wing cases of most beetles and is also very small. The remaining piece is often reduced to a mere ridge assists in the formation of the joints of the wings.

The thorax is united to the abdomen, sometimes closely (*Lepidoptera*), and sometimes by a thin petiole (*Hymenoptera, etc.*).

The Abdomen.

The abdomen (*C*) of insects has never in the adult state any legs. In the larval state legs are present on the abdomen, but these are not true legs, they are only fleshy swellings or prolegs which become lost. The true insect legs are six in number and are only present on the thoracic region. The abdomen of the perfect insect is made up of a number of rings or segments united together by thin membranous interspaces. These membranous junctions allow the expansion and contraction of the insect body. Each segment is composed of a dorsal and a ventral part. In the simplest cases, as in the flea, the dorsal and ventral parts of the segments are composed of one piece each only.

The typical number of segments is eleven and this number can often be recognised in *Neuroptera*. In Bees and Butterflies ten only can be made out, and in certain other cases even fewer. The extremity of the abdomen bears the external sexual appendages (*k*). These appendages

also serve as weapons of offence and defence. In Ichneumon flies we find the end of the abdomen drawn out into a long tube for egg laying (ovipositor). In the Bees and Wasps it has become modified into a sting. The bristles on the end of the *Poduridæ* or 'spring-tails' are also of this class. Another modification is seen in the curious pincers of the Earwig. The Cockroach also carries appendages on the ninth and tenth segments, these styles are no doubt true generative appendages, but they are also said to have some sensory function, possibly of smell or hearing.

The formation of the different genital plates at the end of the abdomen is very important in classification. Dzeidziki, the Russian entomologist finds that the shape of these genital plates and their arrangements are not only typical of certain groups, but form distinctive specific characters.

Stigmata or the breathing pores are also present on each side of the insect's abdomen.

Antennae.

The *Antennae*, feelers or horns, are a pair of processes arising from the head of insects and other Arthropods. They are jointed structures and are extremely variable in form and in the number of their joints. They offer many important points in the classification of insects, and are useful aids to their identification.

In some insects they are present as simple threads (*Tipulidae*) composed of a number of simple joints. In others they are feathery structures (*Bombyx*), in others they are club-shaped (*Butterflies*). In one group of flies the antennæ are composed of a large basal part and a thin thread (*Brachycera*). The May-bugs (*Melalontha*) have antennæ formed of curious lamellæ. 'Elbowed' antennæ are also found (Weevils, Bees), composed of

closely united joints. In certain cases these antennæ are retractile into pits on the head (*Pulicidæ*).

In larvæ the 'feelers' are always very small; sometimes they not present.

The Function of Antennæ.

That the antennæ of insects are sensory organs is now a well-established fact. Whether they are organs of one sense or of a combination of senses is still very uncertain. There is very little doubt that their most important duty is one of *touch*.

These highly sensitive appendages have been studied

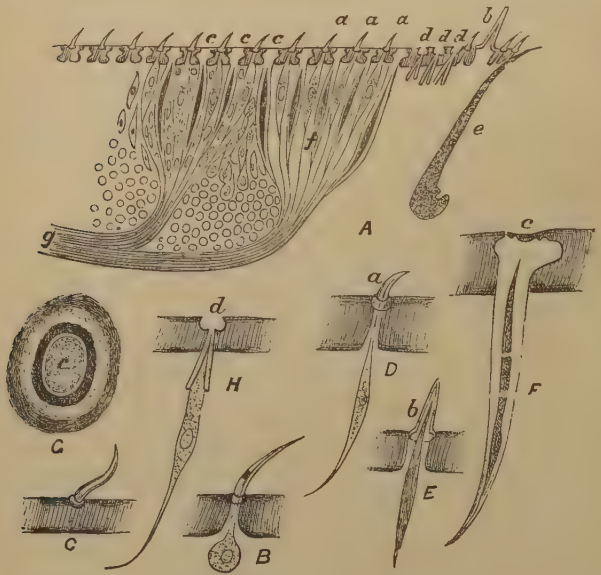

Fig. 6. Structure of Antenna.

by a large number of naturalists and they all agree as to touch organs being highly developed in them. But as we

shall see from the structure, there are other curious sense organs present, which may be either those of *hearing* or *smell*.

Schiemenz has described these antennæ most minutely. According to him each antenna (in the bee) carries as many as six different structures.

If we examine the antenna we shall find the first three joints and the terminal joints of the flagellum, differing from one another and from the remainder.

The back of these are covered with a number of curved hairs, and on the front side, amongst these curved hairs, there are scattered larger ones and pits or oval depressions. And also near to the lower part of these joints patches of small round hollows.

The hairs on the large basal joint (the scape) are as seen in fig. 6 *B*. These are found in many parts of the body. Those on the back of the flagellum are seen at *C*.

Fig 6 *A* Shews a longitudinal section of one of the joints of the antennæ. In *A* will be seen a number of small hairs (*a*). These hairs are set loosely into the antennæ by means of a circular ring, and are connected below with a long nucleated cell (*D*). We also see straight and larger hairs as at *b*, these are also connected with a straight nerve cell (*E*). (These are the *conoid hairs* of Tastkegel.)

Between the 'touch hairs' (*a*) we see depressions or cavities covered by a thin layer, which on the outer surface shows a series of rings. An enlarged section of one of these hollows is seen at *F*. Into the cavity below each hollow passes a nerve end cell. These Schiemenz calls *smell organs*. They are found to be more abundant in the males, especially in the case of species where the females are hidden away and have to be sought after by the male (Bees, etc.).

There are still other important hollows situated in small patches at the lower parts of the joints (*d*). The structure of one of these organs is seen at *H*. The opening leads into a large cavity, from the base of which extends a canal, and inside from the base of this arises a chitinous cone, ending in a fine point below the opening. A nucleated nerve end cell passes into this also. Schiemenz and Hauser consider these also olfactory organs, whilst Graber and Hicks consider them *auditory organs*. The latter investigator calculated there were as many as 20,000 pits and 200 of these cones on each antenna.

That the antennæ are organs of touch there is no doubt. But whether they are also organs of smell or hearing, or both, we cannot at present say. Insects certainly have the sense of smell very well developed.

Most probably the curious structures described are olfactory, but if so where are the auditory organs of insects? There must be some, or else for what use can the 'chirping' of the grasshopper be made?

Eyes.

The eyes of insects are of two kinds, *compound* and *simple*. The former are present in all insects (except some from the interior of Caves), and are large and highly developed sensory organs. The simple eyes are not always present. It is not unusual for the compound eyes of the males to nearly cover the head, they meet together in the middle line (contiguous eyes); in the females they are often widely separate.

Compound Eyes.

On looking at a Butterfly's eye with a lens we at once see that it is divided up into a number of six sided prisms, united closely together like a piece of honeycomb. The

number of these *facets*, as they are called, varies from sixteen to many hundreds. These facets are convex and form the *cornea* of the eye. Each facet is a biconvex lens, perfectly transparent. Under each is placed a crystalline cone (*c c*) ensheathed by pigment cells. Below the cones come the *rhabdia*, which consist of delicate rods having round them and united together the *retinulæ*, about which are placed pigment cells. (p 1, p 2, p 3.) The bases of these rods perforate the *basal membrane* (*m*). Between this and the brain are three ganglionic swellings

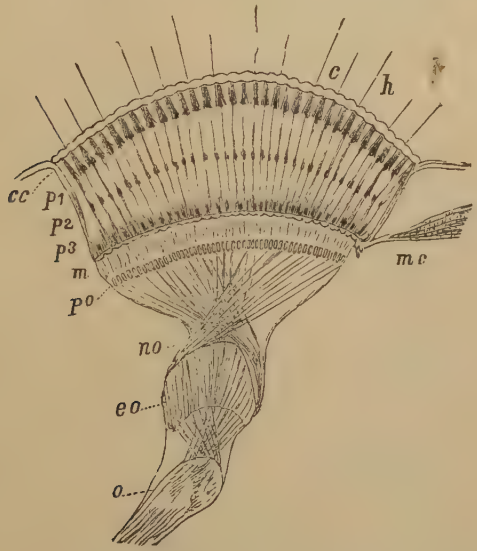

Fig. 7. Longitudinal Section of Compoun Eye.

called the *opticon* (*o*), the *epiopticon* (*e o*) the *periopticon* (*p o*) These three ganglia are connected to the central ganglion.

These compound eyes, although they are made up of many really separate fields of vision (facets) throw only

one object. Müller regarded these eyes as a series of simple eyes and that those rays of light which pass only through the crystalline cones or are reflected from their sides, can reach the corresponding nerve fibril. The others are said by him to be absorbed by the pigment present. No optical image is perceived, as each facet only gives the image of the object exactly in front of it. The picture perceived by the insect is in a mosaic pattern. This, no doubt, is the correct view.

Leeuwenhoek and others considered that each facet throws a distinct image. By holding the cornea of a dragon fly between one eye and a light, it is possible to see the image through the insect cornea. The light will be seen to be inverted and not one light seen, but one in each facet. This gave rise to the theory of each facet throwing a distinct and separate image. In a natural state, or even if only the crystalline cones are left, this is not the case, and for other reasons this theory does not hold good.

Simple Eyes.

The simple eyes, ocelli, or stemmata are present as a rule in insects upon the vertex or crown of the head; they vary from one to three in number.

They have a very convex cornea and the crystalline cone fits into a cup-shaped cavity. Behind this the structure very strongly resembles that of the compound eyes. The ocelli are connected by nerves to the upper part of the brain. What their true function is seems doubtful. Lowne considers that the function of the ocelli is the perception of the intensity and direction of the light, rather than vision in the ordinary accepted term.

They are useful, no doubt, in dark places and for near vision. We find them in the cave insects, well developed when the compound eyes are rudimentary. The compound

eyes of certain water beetles are divided horizontally, so that when swimming they can look up and down. Many interesting experiments have been performed concerning insect vision. We know that they can distinguish colour and that even, as Sir J. Lubbock has shewn, the ants can perceive the ultra-violet rays of the solar spectrum which are quite invisible to us.

The Mouth.

The mouth of insects is modified into three well marked types, the biting, the sucking, and the piercing mouth. The different parts, however, of each type can be connected with the others, although some are only rudimentary and others greatly altered.

The typical insect mouth (Fig. 8) is composed of six

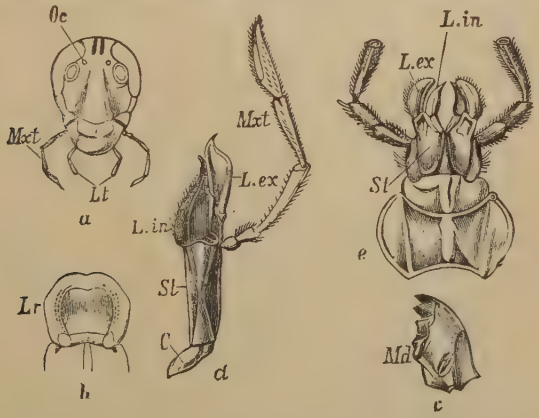

Fig. 8. Head and mouth-parts of typical insects.
a. head, *b*. upper-lip, *c*. mandible, *d*. maxilla, *e*. lower-lip, *C*. Cardo, *St*. Stirpes, *L.in* and *L.ex*. Lobus internus and externus.

articulated pieces, namely, an upper lip or *labium* (*Lr*), a pair of *mandibles* (*Md*), a pair of *maxillae* (*d*) and a lower lip or *labrum* (*e*). The maxillæ (*d*) and lower lip (*e*) have jointed appendages attached to them called palpi (Fig. 8)

(*mxt* and *lt*). Thus the mouth of insects is normally formed of an upper and lower plate with two pairs of jaws between, working horizontally. Such a mouth, a biting mouth, is seen in the caterpillar, some bees and beetles. Let metamorphosis continue and the biting mouth of the caterpillar becomes the sucking mouth of the butterfly.

The *sucking mouth* of the butterfly is composed of a slender trunk, with two scale-like palpi below it. If this thin coiled proboscis is examined it reveals all the six mouth parts. The large upper lip of the larva is replaced by a thin scale-like lamina on the front of the head. On either side beneath the labrum is a pair of scales, the remnants of the formidable mandibles in the caterpillar. The long spiral trunk comes next, this is formed of the long, flexible maxillæ or second pair of jaws and a pair of small palpi at their base. Below this comes the lower lip with large palpi attached. In the house fly and blue-bottle the lower lip is drawn out into a tube or gutter, in which are contained the mandibles and maxillæ, reduced to mere bristles.

In the bee the upper lip and mandibles are strong and fitted for biting, while the maxillæ and lower lip are long and channelled, forming a tube by which the bee sucks up the nectar. The *piercing mouth* is well seen in the bugs (Hemiptera). The mouth of a bug consists of a long tubular labium whose basal part is open or covered by the labrum. The mandibles and maxillæ are altered into piercers or needles, within the tubular labium—much as in the blowfly. In some insects (Oestrus) the mouth parts become very rudimentary or entirely lost.

The Wings.

The wings of insects are always placed on the dorsal surface of the thorax and are normally four in number. They are attached to the second and third thoracic segments.

One pair or both may become rudimentary or lost entirely. In the Diptera the hind wings have nearly gone. In the Orthoptera, the front wings are much smaller than the posterior ones. In *Stylops* they are very minute, and in other insects both pairs are quite absent (*Pulex*, *Mutilla*, *Epidapus*). In the beetles the front pair are horny. Wings are really expansions of the sides of the meso- and meta-thorax, and are supported by strong tubes, called veins, nerves or nervures. These veins contain prolongations of the trachea and nerves and are hardened by the presence of a large quantity of chitin. These membranous expansions are sometimes covered with hairs (*Diptera*), in others by scales (*Lepidoptera*), and in the bees, etc., hooks may be present to connect the front and hind pairs of wings firmly together when flying. The distribution of the veins is an important feature in classification.

The Legs.

The legs of insects are *six* in number. Each leg is composed of six to nine joints. The first, attached to the lower surface of the thorax is known as the '*Coxa*' (*a*) and is succeeded by a short joint, the '*trochanter*' (*b*); the trochanter is followed by a joint, often

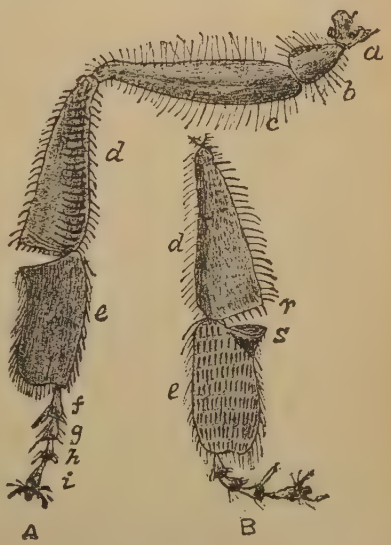

Fig. 9. Leg of the Worker Bee.
r = pecten or comb, *s* = auricle or earlet.

of large size and thickly built, called the '*femur*' (*c*), this is followed by a thin and often long joint, the '*tibia*' (*d* and *h* Fig. 5), the terminal joints being known as the '*tarsi*'. The tarsal joints may number from one to five (*e* to *i*). The different joints are often armed with spines, bristles and hairs. The terminal joint generally has a pair of claws or '*ungues*' (*j* Fig. 5) and between them other structures known as '*pulvilli*', '*onychia*', etc.

The legs are always attached to the pro-, meso-, and metathorax. They become modified into leaping legs (*fleas*), digging legs (*ground-beetles*, *crickets*, *moles*) and long thin legs (*Tipulidae*), other modifications seen in the grasshopper, the Mantes and the Water-boatmen (*Nepidae*).

Internal Anatomy.

The internal anatomy of insects may be treated with under the following heads: The Alimentary Canal, the Nervous System, the Generative System, the Tracheal System and the Vascular System.

The Alimentary Canal.

The alimentary tract of insects commences from the mouth, which leads in masticating insects into the œsophagus by means of a pharynx, the œsophagus is followed by a much folded and membranous crop.

The food from the crop is passed on to the second stomach or strong gizzard. This gizzard or proventriculus is armed with plates and teeth as seen in the cockroach, and is adapted for crushing and triturating food. The true stomach, the chylific ventricle or chylific stomach, the true digestive cavity arises from the gizzard. The intestine is variable in length and ends in a swollen cavity, the cloaca. Into this swelling the generative products also dehisce. The glandular structures attached

to the alimentary canal are three in number. The first or the *salivary glands* are on each side of the œsophagus, and open by a single duct. The salivary glands in the larva are the true silk glands, but after the close of larval life, they change in function and become the true salivary glands of the adult.

The next set of glands are the '*Malpighian Tubules*', these open behind the pyloric aperture of the stomach, into the intestines. They are variable in number and are said to possess the same functions as the kidneys of higher animals. Sometimes these are called *hepatic canals*. Another set of glands, the anal glands, open near the rectum.

The œsophagus is long and narrow in those insects that live by suction, short and thick in those that are carnivorous or herbivorous; it possesses very dilatable walls and passes through the thorax always in a straight line. The crop which, as mentioned above, follows the œsophagus, is particularly well seen in crickets and grasshoppers.

The food is stored in the crop, and in many insects can be disgorged. This is seen in the bee that disgorges the contents of her crop into the cells of the hive to form the honey. In butterflies and other sucking insects, the crop becomes a mere side pocket of the œsophagus and appears to be in reality an appendage.

The gizzard is not found in sucking insects, it is a typical structure of those that are carnivorous and herbivorous. The stomach is very variable in shape; in some it is long, in others short. In the carnivorous water beetles the exterior is covered by a number of tubular glands; but in most insects it is smooth. In the silkworm it forms a long cylinder, but with the change of habits in the silkmoth, the stomach becomes short and enlarged at one end. In the grasshopper it takes a curious heart-shaped form. In the bee there are two cross slits at the

entrance to the stomach and these can be seen opening and shutting by muscular movements. This can be done at will by the insect. It is closed when nectar is wished to be stored; the bee closing the stomach mouth and by contraction of the walls of the honey stomach (crop) the fluid is forced out of its mouth.

The intestine is not so variable in appearance. Its origin is marked by a constriction and by the attachment of the malpighian tubules. It is extremely variable in length in different insects and usually contains a large swelling at the end, the cloaca. In Lepidoptera this is very large, but in the larvæ it does not exist and the intestine is very short.

Digestion.

The food is first bathed by the saliva flowing from the glands on each side of the œsophagus. The saliva of insects is alkaline and not only lubricates the food but aids in digestion. The true digestion of the food takes place in the stomach, which is lined with glands which produce the gastric juice. This liquid is always acid when digestion is going on and possesses the same qualities as that in higher animals—it reduces the food into a pulp and then into chyme.

Nervous System.

The Nervous system of insects is composed of a double chain of nervous matter on the ventral surface of the body. This double chain which has two swellings in each segment of the body, extends from the tail end along the middle line until it reaches the end of the œsophagus, there it passes round it and unites above in the head. The double swellings in each segment are the ganglia, and they are usually closely united together.

The largest is in the head and is known as the brain or *supra-oesophageal ganglia* (*a*). Another large one is also present under the œsophagus, called the *sub-oesophageal* (*f*), the two being united by the œsophageal collar (*g*). The supra-œsophageal supplies nerves to the eyes, antennæ and labrum; the sub-œsophageal supplies the jaws, labium and palpi.

There are also three sets of ganglia in the thorax (*b* and *c*); the prothoracic (*b*) ganglia, supplies the anterior legs; the meso- and metathoracic ganglia (*c*) supply the middle and posterior legs and the first and second pairs of wings. The abdominal ganglia vary in number, in the larva one is present in each segment, but during the processes of metamorphosis not only do the thoracic ganglia become united, but even greater concentration takes place in the abdomen. The segments being much fewer in the imago than in the larva, is the cause of this concentration. In the queen bee the abdominal ganglia are only four.

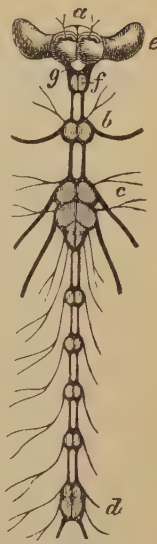

Fig. 10. Nervous System.

All the three thoracic centres may unite into one mass, but as a rule the second and third only are concentrated together. The optic nerves and the nerves to the antennæ as well as those to the upper lip and the ones encirclin gthe œsophagus, spring from the bilobed mass of the brain. Those that supply the compound eyes are so large that they appear to be part of the brain. In many cave insects these are, however, very small (= 3rd pair). The nerves supplying the ocelli also arise here and are called the first nerves. The antennæ are supplied by the second pair. The sub-œsophageal gives rise to the nerves

supplying the masticatory organs, viz., to the maxillæ, mandibles and lower lip. The three thoracic ganglia which are always separate in the larva become more or less united in the adults. In Coleoptera, Orthoptera, and Hymenoptera the first thoracic ganglion seldom fuses with the meso- and metathoracic. The two latter invariably unite. From the three thoracic ganglia nerves arise to supply the legs and wings. During the chrysalis stage the centres in the abdomen also concentrate. No sooner does transformation take place than the ventral cords become relaxed and wavy. Gradually they shorten, and in this way the ganglia are drawn together. In the butterfly it is seen that the ganglia of the first two segments of the larva have disappeared by uniting with the enlargement in the metathorax and those of the four posterior rings have become united into one.

There are also sympathetic nerves which commence, according to Blanchard, from the œsophageal collar. They soon reunite and have in each segment of the body a triangular ganglion which sends off fine nerves to all parts of the body.

Respiratory System.

Insects do not breathe as we do, through the orifices in the head, but through special apertures along the body. These apertures or breathing pores of insects are called *stigmata* or *spiracles*. Each spiracle, which is in the form of an oval slit, consists of two openings, an inner one being closed by a valve, and an outer one being protected by hairs.

From these spiracles arise tubular structures known as *tracheæ*, (Fig. 11) which branch in all directions through the body, becoming smaller and smaller. In the larvæ the tracheæ form a simple system of tubes arising from

a longitudinal one on each side of the body. But in flying insects the spiracles open into large air sacs or vesicles, swollen tracheæ. The tracheal tube is a somewhat remarkable structure, composed of an inner (mucous) layer (*a*), and an outer (serous) membrane (*b*), between these two there is a spiral band (*c*), giving the tube a striated appearance. These spiral bands are simply inward foldings, with thickenings of the chitinous wall, and are extremely elastic. In the bee the vesicles, from which spring small tracheæ, are large structures, being especially developed in the anterior part of the abdomen; they, as are also the longitudinal vessels of the larva, are united to one another by transverse tracheæ. The size of the vesicles and the distribution of the tracheæ vary in nearly all insects. The spiracles are, as a rule, found along the side of the body (abdomen) and one or two on each side of the thorax. In many parasites, as *Hypoderma bovis*, the spiracles, in the larva, are situated on the tail. But amongst the aquatic forms we find the most modifications.

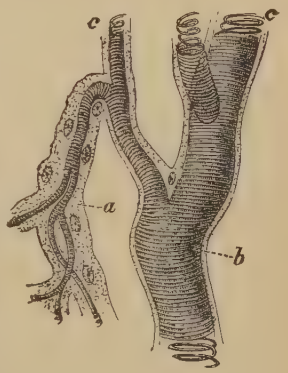

Fig. 11. Tracheæ.

The water beetles (*Dytiscidae*) have them upon their back under the elytra, so that when they want to breathe they come up to the surface and open the wing cases and take in air. We see further modifications in the case of gnat (*Culex*) larvæ, where the tail is the region where air is taken in; the orifices being surrounded by dense hair. The larva comes to the surface and thrusts its tail into the air. In the nymph stage the spiracles become set in two tubes projecting from the thorax, and respiration is carried on in a similar way.

It is probable that the large vesicles are developed to alter the specific gravity of the insect when flying, the sacs being filled when flight is about to take place.

In certain aquatic larvæ the respiratory apparatus is in the form of branchiæ or gills, which become cast off on assuming the adult form (*Ephemeridae*, etc.).

The tracheæ arise as invaginations, and so the lining membrane is really the outer membrane. The linings are cast during the moulting of the larva.

Vascular System.

Insects have organs of circulation although no regular system of blood vessels.

There is a large dorsal vessel, the *heart*, which contains a series of cavities, the *ventricles*. The ventricles have openings on each side.

Fig. 12. Dorsal vessel or heart.

The heart is situated immediately under the dorsal integument and extends from near the apex of the abdomen to the œsophagus, at which end it is open, near the brain. Each ventricle communicates with the one before it by means of a valve, so the blood flows in one direction.

When the heart is contracted the blood is forced out at the head end and permeates every part of the body. When expanded the side openings of the ventricles admit the entrance of the blood, and the valves between the ventricles shut. Then on

the following contraction they open, and so the circulation is kept up.

The blood of insects is colourless and contains white amœboid corpuscles, analogous to those found in the higher animals. It has been shown that the speed of circulation alters with the temperature, and also that temperature has much to do with the pulsations of the dorsal vessel, which cease at freezing point.

Whilst the general belief is that there is no regular system of blood vessels and that the blood simply circulates through the interstices of the tissues, some observers affirm the partial existence of a true vessel system, whilst others state that the blood circulates between the tracheæ and their enveloping sheaths, which are thus really blood vessels as well as air tubes.

Generative System.

The sexes are, as a rule, distinct in Insects, but occasionally hermaphrodites are found (Bees, etc.).

The male organs consist of two testes, two tubes, the vasa differentia, two seminal vesicles and two large mucus glands, and a ductus ejaculatorius. There is also often present a rounded white body, the 'bean', united by four scales (rudiments of the genital armature). The spermatozoa are forced into the 'bean' and form the spermatophore.

The female organs consist of two pear-shaped ovaries, beneath the 2nd and 3rd abdominal rings, each ovary being composed of a large number of tubes or 'follicles'. The two ovaries open into two oviducts, which unite and form a single tube. This enlarges posteriorly to form the vagina, which has on each side swellings, the 'bursa copulatrix'; a globular swelling, the 'spermatheca', is also present for the reception of the spermatozoa, opening into the oviduct.

CHAPTER IV.

COLEOPTERA OR BEETLES.

General account of order—Adephaga—Palpicornia—Brachyelytra—Necrophaga—Lamellicornia—Sternoxi—Malacodermata—Teredilia—Heteromera—Rhynchophora—Xylophaga—Longicornia—Eupoda—Pseudotrimera.

THE *Coleoptera* or Beetles form a very extensive and compact order of insects.

They are characterised by the possession of four wings, the front pair being horny and forming a case or protection to the posterior pair, which are membranous. The front pair or *elytra* meet in a straight suture down the back when they are closed. They are mandibulate insects, with a complete metamorphosis. The larvæ may have six legs or may be apodous. The pupæ are always inactive.

No order of insects has been so widely collected as the one we are dealing with in this chapter, collections having been made from all parts of the world. They are not, however, so interesting a group as we should expect from the great amount of labour spent on them. Their hard wing cases protecting them and their general solid appearance make them easier to collect when travelling in foreign countries than other orders. At the present time there are over 100,000 beetles known, that is nearly

half the known insects of the world. In our own country they number over 3000, or nearly one fourth of our total insect fauna. There are great modifications in their structure in the even closely related groups, but we shall find no such interesting points as in the more highly developed Hymenoptera. It is said that Beetles are found in nearly every part of the earth, their hardy nature rendering them easy of transportation from region to region, not only by artificial but also by the more important natural agencies.

The Coleoptera are an extremely old group of insects. Their remains are found in the Palæozoic rocks, the Silesian culm of Steinkunzendorf having furnished no less than five beetle remains. No doubt the borings so often found in the fossil wood of Carboniferous age are also due to some wood boring beetles of that Period. In the Trias they become more abundant, whilst the Jurassic rocks have yielded numbers of 'Weevils'. They become more and more abundant as we reach the Upper Tertiary beds, and the order has attained its maximum development at the present day.

The methods of classifying the Beetles are somewhat varied and not at all satisfactory. The old classification was by the number of joints in the feet. Those with five joints were called the *pentamera*, those with five in the four anterior and four in the two posterior feet, the *heteromera*. The *tetramera* were those with four joints in all the feet, the *trimera* with never more than three joints to all the tarsi. This classification is not a natural one, we should find most diverse creatures closely connected together and similar forms widely separated.

The German and American coleopterists do not attempt to group the beetles in higher divisions than families. English and French authorities, however, unite them into larger groups.

The classification followed here is that adopted by Kirby.*

The order being divided into a number of sections, the characters and examples of the most important families of each being given in the following pages.

Adephaga.

The beetles belonging to this section have five jointed tarsi, and filiform antennæ. By far the greater number of the species in this section are carnivorous, but there are some which are occasionally very destructive to vegetation. There are two groups or sub-sections, the *Geodephaga*, which have the mandibles exposed and have large and prominent eyes, usually land forms; and the *Hydradephaga*, which have the mandibles concealed by the upper lip and are aquatic insects, their legs being adapted for swimming.

The *Geodephaga* or Carnivorous Ground Beetles are a very extensive group and of considerable importance to us agriculturally, as many of the species are decidedly beneficial whilst others have recently been shewn to do much damage locally to both root and cereal crops. This group includes two families, the 'Tiger Beetles' or *Cicindelidae*, and the 'Ground Beetles' or *Carabidae*.

The Tiger Beetles or *Cicindelidae* are often very beautiful creatures. The Common English Tiger (*C. Campestris*) found also all over Europe, North Africa, and Asia Minor is of a bright sea-green colour with a few creamy spots upon the elytra and with the edges of the elytra, the head, and ventral surface brilliantly coloured with coppery tints. They have all long and elegant legs and are extremely active creatures, running rapidly about in search

*Elementary Text Book of Entomology. Kirby.

of prey. The head, as in all the Cicindelidæ is armed with very large scissor-shaped jaws, large palpi and toothed mandibles. They may be seen running and flying about in sandy places, often abundantly, especially in dry and warm weather. They are solely carnivorous. So also are the larvæ, which have the same bloodthirsty characters as the adults.

The larvæ, however, have a soft body, not protected, as are the beetles, by the elytra, and so cannot expose themselves in the same bold way when hunting for prey. They have six short spiny legs which enable them to dig holes in the ground. They burrow down vertically at first, thrusting out the earth, as they go, with their flat heads. After burrowing a short distance vertically they tunnel horizontally and then turn round with their head to the exit. There are two curious fleshy tubercles and curved hooks upon the very swollen fifth segment; by means of these hooks the insect fixes itself against the side of the tube and then covers the entrance. Beneath this trap the voracious larva waits with its jaws open, ready to take any insect that passes over the treacherous ground. Eventually an ant or some small insect passes over it and falls down. It is at once seized upon by the foe within and dragged deep into the burrow and there speedily devoured. The larval head really forms the floor of this ingenious trap, the instant anything touches it, the head is lowered and the prey falls in.

The *Carabidae* have the maxillæ terminating in an unarticulated point; head narrower than the thorax, unlike the former family which have a broad head. Mandibles large and strong but with no prominent teeth as seen in Cicindela. This is a very important and extensive family, and includes a very large proportion of our native species. Some are found only in marshy places, others love dry

soil, whilst others frequent the sea shore only. They are nearly all carnivorous. The genus *Carabus* is the most typical and important. They generally come out to hunt at night and are extremely active insects. Two of our commonest are *Carabus Catenulatus* and *Violaceus*, large purplish-black beetles with smooth elytra. Another often met with is *C. nitens*, a beautiful greenish beetle, glossed with a metallic coppery red.

Carabus auratus, which is common in France and called by the country people the 'gardener' or 'sempstress,' may also sometimes be seen running about in search of prey. All these Carabi destroy large numbers of insects, but still they are killed whenever they are seen by people not acquainted with their habits, instead of being preserved. The larvæ are shining black in colour and long, the head and segments being covered by a hard integument, so as to protect them when hunting for their prey, which like the adult they do at night. Their mandibles are arched and have a large tooth at their base, in some these teeth are very large and give the creature a fierce appearance. The six legs are long, the larvæ very active; the end of the abdomen is generally furnished with two jointed appendages and a tubercle.

There is another important species belonging to the genus *Calosoma* found occasionally in England upon oaks; it is *C. Sycophanta*. Although only now and then found in our country it is common on the Continent. The thorax of this genus is much narrower than the abdomen, and the wings are well developed, whereas in Carabus they are absent. The species referred to is of a beautiful golden-green colour and feeds almost entirely upon the hosts of Processionary Caterpillars (*Cnethocampa Processionea*) which are so often seen crawling up the oaks in France. The larvæ are just as rapacious as the beautiful active

adult. They turn to the nymph in a case beneath the soil.

Another curious genus is *Brachinus*. This genus includes several small reddish beetles about the quarter of an inch in length, with bluish elytra. They are popularly known as 'Bombadiers,' on account of a curious method of defence they employ. It is well known that many of the Geodephaga emit an acid fluid when attacked, but Brachinus when alarmed, emit an acid which volatilises into smoke and causes a slight explosion. The genus *Aëpus* is another of interest, as the three very small apterous yellow beetles which it includes are only found on the sea shore, at low water mark, and are covered by the tide for several hours every day. Blind Carabi are also found in the great caves of S. E. Europe and North America, belonging to the genera *Anopthalmus* and *Aphaenops*.

So far as we know at present only one species does any appreciable amount of damage to our crops, this is *Zabrus Gibbus*, a highly destructive insect locally. It is of a shiny black colour, with pitchy brown antennæ and legs. It is cylindrical in form and is winged and measures about half an inch in length. The larvæ which are pale bright brown have a very large head and sharp jaws; they live in tunnels in the ground, crawling out at certain times upon the surface. They are often turned up in large numbers by the plough and are devoured by the Rooks, Gulls and Starlings. They pupate deep in the earth. Both adults and larvæ are destructive to corn, and during 1892 root crops were also attacked by them. As this is a comparatively new pest in England, very little is known of its habits.

The *Hydradephaga* are the water-living sub-section, their legs being adapted for swimming. They can also fly, and many of these aquatic forms can be taken on the wing;

they are entirely carnivorous. There are two families, the *Dytiscidae* and the *Gyrinidae*. The former are large beetles with long filiform antennæ and short palpi; the hind pair of legs fringed with hairs; eyes not divided. The genus *Dytiscus* contains the largest species, the 'Great Water Beetle' (*D. Marginalis*) being the example we take. It is a large insect, sometimes reaching an inch and a quarter in length and being very solidly built. The male has quite smooth elytra, whilst the female has grooved ones. The first pair of legs in the male have the three basal joints of the tarsus flattened and widened, forming a kind of cushion. Beneath, this cushion is armed with a number of small suckers and with two very large ones. The front legs of the female are simple. The hind legs are fringed with hairs and serve as oars to propel the beetle when swimming. A large pair of wings are present. The wing cases do not fit closely to the body, but are arched, so as to leave a cavity between themselves and the dorsal surface. This cavity is formed as a reservoir for air. When the beetle wishes to breathe it comes to the surface, opens its elytra and takes in a quantity of air, which is drawn in by the spiracles, present along the insect's back. The larvæ of these large brown water beetles are often called 'fresh-water shrimps'. They have large heads armed with a pair of sickle-shaped jaws, these jaws are hollow and through them the juices of the prey are drawn; the six legs are well developed on the first three segments, and the anal segment, which is long, is armed with two feathery gill structures, through which the larvæ breathe, much in the same way as will be described in the gnat. When full grown, the voracious creatures, which will devour even their own race, reach sometimes 2½ inches in length. They crawl to some muddy bank and there having formed themselves a cell, the pupal stage is assumed.

The next family the *Gyrinidae* are represented by the Whirlwig Beetles, little glossy creatures that form those curious circular dances on the water. *Gyrinus natator* is one of the commonest, it has deep blue glossy elytra and is about $\frac{1}{4}$ of an inch in length. It will be seen that the compound eyes are arranged in four groups, two above and two below. The larvæ are greyish white creatures and have a curious breathing apparatus, in the form of eight pairs of very delicate filaments and two pairs also on the anal segment. The pupal stage is passed in a silken cocoon attached to the stem or leaf of some water plant.

Palpicornia.

This section contains only one beetle of importance to us, namely the 'Harmless Water Beetle,' belonging to the *Hydrophilidae*. The Palpicornia have four palpi, the maxillary ones sometimes being longer than the antennæ. The antennæ are short and clavate.

The Harmless Water Beetle, *Hydrophilus Piceus* (fig. 13),

Fig. 13. Hydrophilus Piceus.

is one of our largest water beetles; it is oval in form, but narrower and more convex than Dytiscus. The long palpi and the short antennæ will at once distinguish it from the Great Water Beetle. The adult is herbivorous but the

larvæ are just as fond of animal life as are those of the Dytiscidæ. The larvæ are oblong, with large mandibles which are curved and dentate, they are greyish white and have coriaceous plates in the integument. They pass on to the land and may often be found crawling about in damp places near pools. The female Hydrophilus lays her eggs in a mass of silk, forming an impervious cocoon, protecting them until they are hatched. The pupal stage is passed in a cavity in the mud in the same way as in Dytiscus.

Brachyelytra.

The elytra in this section are very short, but the wings

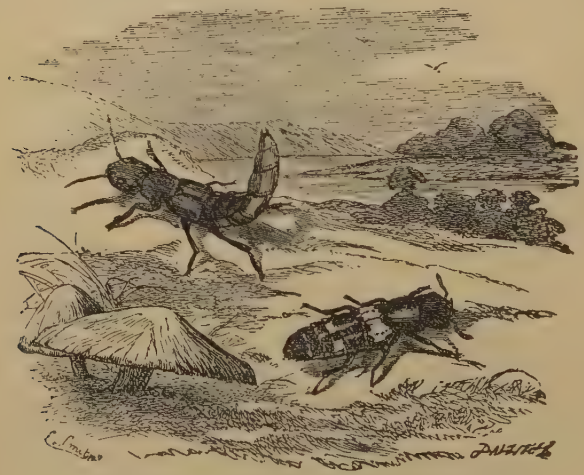

Fig. 14. Ocypus olens and Creophilus maxillosus.

are large and fold up under them. Palpi four, antennæ short.

There are two families, the *Staphylinidae* with slender antennæ; elytra usually much shorter than half the length of

the abdomen which is freely moveable; tarsi 5-jointed. The second family, *Pselaphidae*, have short thick antennæ, elytra nearly half the length of abdomen, tarsi 3-jointed, abdomen not freely moveable. The most typical member of this section is the 'Devil's-Coach-Horse' (*Ocypus olens*) (Fig. 14). It belongs to the first family and is a black insect, with the antennæ tipped with red. It may often be seen running about cellars and gravel paths. When frightened it turns up its head and tail and emits a disagreeable smell. Its large jaws are used in catching its prey, for these Devil's-Coach-Horses are purely carnivorous. The larvæ very much resemble the adults but have no wings or elytra developed, they hide under stones and wood during the day and crawl out in search of prey at night. The pupal stage takes place beneath some stone or lump of earth. The pupa is yellow and armed with a tuft of hairs in front.

The *Staphylindae* contain a large number of forms, some being herbivorous, many living upon manure. Most are small insects and they are generally dark in appearance. There are some interesting members of this family found in the nests of the *Termites*, which have their abdomen very swollen and turned up so as to rest upon the back. This swollen abdomen is filled, not with eggs, but with young larvæ. This is one of the very few cases in the Coleoptera of the production of living young.

Necrophaga.

The *Necrophaga* or *Clavicornia* are a large and varied group and contain a number of families. They are the great 'scavengers' of the earth, feeding upon decaying animal matter and manure. Some few are found to live in ants' nests. The majority may therefore be called 'beneficial insects', but one family, the Dermestidæ, are

decidedly destructive. This section is characterised by the following points; tarsi generally 5-jointed, antennæ of moderate length, generally clavate; the abdomen nearly covered by the elytra.

The family *Silphidae* contains the most important species. The Silphidæ are characterised by their 5-jointed tarsi, their 10- or 11-jointed antennæ, the last four of five joints forming a club; the head frequently narrowing behind into the neck. The most important of this family is the

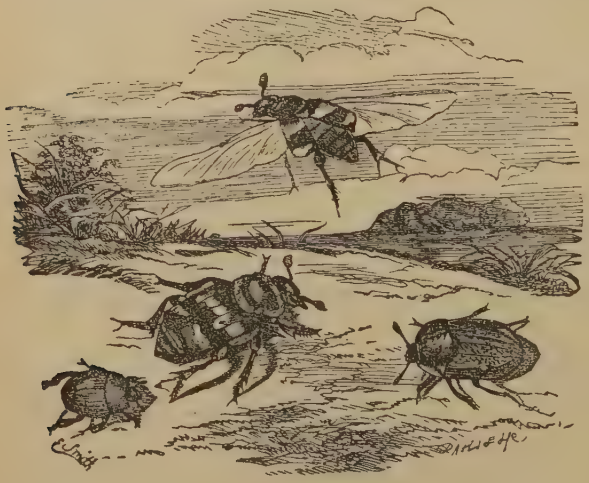

Fig. 15. Necrophorus and Silpha.

genus *Necrophorus* or the 'Sexton' or 'Burying Beetles' (Fig. 15). The members of this genus are pretty insects, the dark elytra being banded with a bright orange colour and several of them being densely hairy. They are called Sexton or Burying Beetles, on account of a curious habit peculiar to them. They live not only in the adult but in the maggot state upon decaying animal matter. When they come across a dead mouse or rat they at once set to

work, not to devour their trophy, but to bury it beneath the ground. As they are not strong enough to drag the animal into a hole dug first, they have invented the ingenious method described below.

If you lift up a dead mouse you will often find beneath it the black and orange beetles we are here considering. They are there for the purpose of burrowing, loosening and scraping away the earth beneath the mouse, so as gradually to lower it into a hole. They commence at first at the sides and then beneath, until the animal is buried. The object of hiding this dead animal is so that their eggs which are laid in it are placed in a safe position. The larvæ which hatch from the ova feed upon the decaying flesh. They are white maggots, which pass deep into the ground to pupate. In this way much good is done by these 'Sextons', as dead animals are stopped from putrefying in the air as they would otherwise have done.

The injurious Beet-Carrion Beetle (*Silpha opaca*) is partly a scavenger and partly a vegetarian. The beetle (Fig. 15) lays her eggs in putrid matter upon which the larvæ live. Often, however, the larvæ are carried in manure to the fields where they attack beet and wurzel foliage. The ova also appear to be deposited direct upon the leaves now and then.

The other family we will consider is the *Dermestidae*, they have also 5-jointed tarsi, short clubbed antennæ and long bodies. They are all small and of a grey, brown or dusky colour. They do much damage to manufactured animal matters in their larval state. The so-called Bacon Beetle (*D. Lardarius*) is one of these. It is a black insect, with the bases of the elytra fawn coloured and marked with three dark spots. The larva which does so much damage is blackish brown, covered with long tufts of hair, which are placed regularly on the margin of each segment.

These larvæ live upon furs, hides, and they not unfrequently attack hams and other stored goods. *D. vulpinus* works also in a similar way and formerly did much damage to furriers in London. The only practical way I know of destroying them in warehouses is by bisulphid of carbon; they have to be subjected to the fumes, however, several times to completely clear the warehouses of them.

The family *Nitidulidae* must not be passed over, as it contains the genus *Meligethes* to which belongs the destructive 'Mustard Blossom Weevil' (*M. aeneus*). The family has 5-jointed tarsi, the first three generally enlarged, the fourth very minute; antennæ with a 3-jointed club. The 'Mustard Blossom Weevil' attacks the flowers of the mustard just when they are commencing to burst. It is a small beetle only about $\frac{1}{12}$th of an inch in length and of a dull brassy green. The larvæ live upon the flowers, leaves and seeds of the mustard, and often do much damage to the crops. The beetles feed upon the pollen.

Lamellicornia.

Antennæ short, 9- or 10-jointed and terminated by a large abrupt 3-jointed lamellated or pectinated club. The outside of the front tarsi always serrated.

This section contains many large and curious beetles, not only abroad but in England. There are two families and a large number of sub-families, the most important being the *Lucanidae* or 'Stag Beetles', the *Scarabaeinae* or Sacred Beetles, the *Melalonthinae* or the Cockchafers and the *Cetoninae* or Goliath and Rose Beetles.

The *Lucanidae* have 10-jointed, angulated antennæ with a large pectinate club, with large mandibles in the male. The Common Stag Beetle (*L. Cervus*) may be taken as an example. These large black insects with

brownish elytra measure more than two inches in length and are the largest British insect of this order. In the male the mandibles reach an immense size, but in the female they are small. The larvæ are large white fleshy grubs, which feed in the rotting wood of trees. Some of the exotic species are brilliantly coloured, but the majority are black or brown insects.

The *Scarabacidae*, the second family, is divided into a number of sub-families.

The family characters are the non-angulated 8- to 10-jointed antennæ, terminated by a large lamellated club, usually composed of three plates. The curious Egyptian Sacred Beetle (*S. sacer*) belongs to this family and with a few others forms the sub-family *Scarabaeinae*. The *Melalonthinae* are an extensive group containing the Cockchafers.

The Cockchafer.

The Common Cockchafer (*M. vulgaris*), Fig. 16, is a large beetle about an inch in length and is terribly destructive to vegetation, both in the larval and adult states.

Fig. 16. Cockchafer and Grub (*Melalontha vulgaris*).

The beetle, which is brown, in densely covered with down on the breast and other parts. The elytra have five

ridges running along them. The abdomen is pointed and marked at the sides with alternate patches of black and white. The antennæ of the male have seven lamellæ, of the female only six. These beetles lay their eggs in the ground, and from them hatch white maggots. The larvæ when full grown reach 2 to 2½ inches in length, and are white fleshy looking creatures with the end of the body swollen into a large sac; six legs are present in front and the head is brown and horny. They are usually found in a bent position, when turned up, as they often are, by the plough. The larval life often lasts three years, during this period they devour the roots of various plants and trees. Wheat, roots, grass are all attacked, but perhaps the most damage is done to sapling trees, especially oaks. They pass deep into the earth to pupate, sometimes two or three feet. The pupæ are present in a cell and give rise to the Chafer some time before it makes its appearance above ground. The beetles also do much damage to leafage of forest trees, when they appear, as is not unusual, in large swarms. Strawberries have also suffered during recent years, both from the maggot and beetle.

To this section also belong the Rose-Chafers and Goliath Beetles (sub-family *Cetoniinae*).

Sternoxi.

The *Sternoxi* are a very important section, for they contain the family *Elateridae* or Click-beetles, the adults of the devastating Wire-worm. This section is characterised by possessing 5-jointed pectinated or serrated antennæ; the prosternum dilated in front and often produced into a point behind; the body long and narrow; vegetable feeders only. The family *Elateridae* besides including the Click Beetles, also includes the fire-flies of the Tropics.

They are all adapted for leaping and have a more or less oval body, with the hind angles of the thorax often produced into spines. There are a large number of species found in England, *Agriotes lineatus* being one of the commonest and doing most damage to the crops.

The Click Beetle (Wire-worm) *Agriotes lineatus*.

No insects do so much damage as the 'Wire-worm.' They arise from eggs laid by a beetle known as the 'Click-beetle' or 'Skipjack.' There are many kinds of these 'Click-beetles', but there are only four that are recorded as doing damage to our crops. The most important of these is the striped Click (*Agriotes lineatus*); this species is reddish-brown in colour and has a coating of short greyish down over the body. The elytra are very convex and are marked with longitudinal striæ. The legs are very small. The mesosternum has a notch in it and into this fits a projection from the prosternum. Now when the insect falls on its back, its legs are too small to allow it to regain its normal position, and it has to have recourse to another method. The modifications on the pro- and meso-sternum are for this purpose. The beetle presses its head against the ground and arches its body, it then relaxes the pressure and the point of the prosternum springs into the notch already mentioned, the result being that the insect is thrown into the air some distance and sooner or later falls on its feet. A curious clicking sound is produced at the same time, hence the name 'Click Beetles'. The female *lineatus* lays

Fig. 17. Click Beetles and Wire-worm. *Agriotes lineatus* and larva. *Athöus haemorroidalis*.

her eggs in the ground or at the roots of plants, and shortly they hatch into young larvæ (wire-worms). They are called Wire-worms on account of their curious wiry and hard appearance. They are shiny, and yellow to brown in colour, and always have six horny legs in front and a fleshy proleg on the anal segment. These points distinguish them from other grubs often called wire-worm but quite distinct, *viz.*, the 'Leather Jackets' or larvæ of the Daddy-Long-Legs (*Tipula*) and from the Centipedes and Millipedes. The wire-worm lives some three or four (occasionally five) years in the larval stage, feeding all the time, except during the cold winter months. During the cold frosts they pass deeper into the earth. They attack the upper part of the roots of plants, especially wheat, roots, and fodder crops, and occasionally they work up the stem, as in cabbages. Their work is best seen in a field of wheat, where they can be watched day by day working up to the drills and causing the plant to turn yellow and flag. Mustard, Flax, Vetch, and Tares appear to be the only crops not severely attacked. They turn to pupæ in an earthen case deep in the ground and may appear after three weeks' quiescent life or may remain in that state until the following year. Hops are particularly attacked, especially when the land has been broken from grass or clover lay. Wire-worm apparently have a strange dislike to sea-weed on the land, for where this is used as manure few wire-worm are seen.

Land should be well cleaned after clover lay; for it is found they are always more abundant after clover. The land should be fed down close by sheep and then dressed with gas-lime before ploughing up.

Ploughing in a green crop of mustard is also found to make the ground obnoxious to wire-worm. Heavy rolling

with a Cambridge Ring Roller is also beneficial; the harder the ground the less easily can the wire-worm work. Paring and burning is also strongly recommended, as this not only kills the wire-worm but weeds and other pests as well. The application of artificial manures, nitrate of soda, etc., according to the crop, is found to carry the plant past attack and in many cases has saved the crop from destruction.

The encouragement of Rooks, Starlings and Gulls should be the aim of every farmer. The two former birds feed on grubs and do more good in a day than all our attempts for years to destroy this pest. There is also a good way of stopping the damage in hop fields and gardens, by means of 'traps'. Pieces of potato or rape-cake put around the hop hills and in the ground in gardens attract the 'worm' for some distance around. They can then be collected and burnt or otherwise destroyed. Moles should also be encouraged, especially in hop gardens where they are known to do much good in devouring these larvæ.

Malacodermata.

The insects in this section have, as a rule, a more or less soft body. Prosternum not dilated in front and seldom produced into a point behind. Abdomen with six or seven segments. This section includes amongst many others the family *Lampyrinae*, or the 'glow-worms'. The head in this group is more or less concealed by the thorax; eyes in the male are very large, elytra in the female often wanting; segments of the abdomen may be phosphorescent. In England especially in the south, the glow-worm (*Lampyris splendidula*) is not an uncommon sight in the hedgerows on a warm summer night. The male is brown in colour and has large elytra, the head being hidden under

the thorax; it is usually about half an inch in length. The female is quite unlike the male and has no wings, and she gives forth a powerful phosphorescent light of a greenish-blue hue. This light proceeds from the under side of the last abdominal segments. The male also has this light-producing character. The larvæ resemble the females and live upon snails, slugs and other insects.

The Fire-flies of the South of Europe belong to this family as well.

Teredilia.

This section contains a number of small beetles often terribly destructive to wood, not only out of doors but within houses also. The tarsi are generally 5-jointed and the body hard; prosternum simple; antennæ filiform; abdomen usually composed of five segments. Most of the larvæ belonging to this section are wood-borers.

A common English example is the well-known *Anobium tessellatum*, one of the family *Ptinidae*. This little beetle is about $\frac{1}{6}$th of an inch in length and of a rusty brown colour, the thorax and elytra being covered with little patches of yellowish down arranged in a regular pattern. The larvæ of the beetle are very destructive to furniture. The male of this species, and the same may be said of many others, attracts the female's attention by tapping his head against some hard substance, producing a curious clicking sound. By superstitious people this is considered an ill-omen and hence the name of 'death watch' is often applied to this insect. There are many others equally destructive to furniture and timber in this group; others destroy fungi, *Cis boleti* being one of the latter.

Heteromera.

This is a large section and many of its species resemble the Carabidæ in appearance, but the four front tarsi being always 4-jointed and the hind ones 5-jointed together with the moniliform or bead-like antennæ, will always distinguish them.

The Cellar beetles (*Blaps*) are members of this section and belong to the family *Terebrionidae*, so also are the black beetles that give rise to the 'meal worm' (*Tenebrio molitor*).

The perfect beetle of the meal worm is black, and about half an inch long, with striated elytra. The larvæ, which are large smooth yellow creatures with the six legs well developed, are found abundantly in flour and in bran, where they feed and make their pupal cells. They are also sometimes abundant in ship's biscuits.

The family *Cantharidae* is also of interest, as it contains the curious oil beetles (*meloë*). The antennæ in this family are 9- to 11-jointed, slightly thickened at the tips; elytra soft, long and narrow or else very short; the larvæ are often parasitic. The 'oil beetles' are large purplish-coloured beetles, measuring sometimes an inch and a quarter in length. They have a large swollen soft abdomen, soft elytra, and no wings.

The female lays her eggs in batches of some hundreds in the grass. These ova hatch into very active six-legged maggots that at once crawl up the flowers, especially those frequented by bees. They become attached to the bee and, clinging to it, they are taken off to its nest. There they become deposited and commence to devour the eggs in the cells. They then change into another form of larva and commence feeding on the pollen collected

for the larval bees. Later they undergo another change of form and become in time pupæ.

All these oil beetles have a curious habit of pouring out an oily excretion from the joints of the legs when touched.

Stylopidae (Fig 18) are a family closely related to the one just mentioned. The *Stylopidae* were formerly considered a distinct order of insects, and were called *Strepsiptera*. The elytra are very short: hind wings broad and folded longitudinally; tarsi 2- to 4-jointed, antennæ bifurcate or ramose; metathorax very large; females apterous.

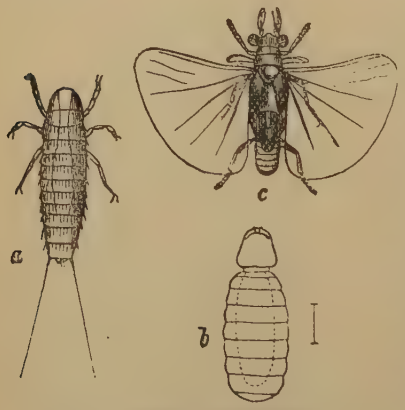

Fig. 18. *Stylops Childrenii* *a*. larva *b*. female *c*. male.

They are all parasitic on various bees and wasps during the larval (*a*) and pupal stages, and in the perfect stage of the female (*b*). The males (*c*) are free, and pass their time in the air; the females remain in the bee's body, only their heads protruding between the segments of the bee. The effects of this so-called 'Stylopization' on the bees is very marked and curious, greatly altering their appearance.

Rhynchophora.

This is the important and extensive group of Weevils, and is characterised by the head being produced into a

Fig. 19. Nut Weevil. (*Balaninus Nucum*).

rostrum or snout upon which the antennæ are placed; the antennæ are 6- to 10-jointed and are angulated beyond the long scape. The elytra cover the abdomen and are very hard. The two important families are the *Cuculionidae* (Fig. 19) and the *Bruchidae* (Fig. 20), the former family has elbowed antennæ and the latter straight antennæ. Both families include a large number of insect pests, and we will take one or two of these as examples for fuller description.

Pea and Bean Weevils.

(*Sitones lineatus and crinitus*)

The Striped Pea Weevil, *Sitones lineatus*, is a small beetle about $\frac{1}{4}$th of an inch long, of a light yellowish-brown colour. There are three pale yellow stripes on the thorax and ten of a paler hue along the elytra. The antennæ and legs are reddish. The Spotted Pea Weevil, *S. crinitus*, is of a greyer appearance, smaller than *lineatus* and hairy, the elytra are marked with a number of black spots and bristly hairs. These Weevils lay their eggs at the roots of the pea and clover. The ova soon hatch into small white maggots with brown heads; these at once set to work to destroy the roots of the plants; the author has found as many as fourteen on one root of clover. They are found at the pea roots during May and June and at the clover roots during the winter months. They turn to the pupal stage in an earthen cell in the ground

about two inches below the surface. The chrysalis is at first white, but as it becomes matured it becomes darker in colour. The perfect Weevils hatch in about three weeks. Not only do the *larvae* damage the roots, but the imagines also do much harm. Every gardener and farmer is acquainted with the curious notched appearance of the young pea leaves, at some seasons reaching such an extent as to entirely destroy the crop. This is the work of the 'Weevils'. If we walk quietly down a row of peas on a warm day and look at the leaves, we shall see these beetles sitting upon the leaf with the edge between their two front legs, devouring rapidly the substance of the leaf. A certain number of these Weevils live through the winter, hibernating in some barn or, as it also appears, in the barley stubble or rick. These, no doubt, are the ones that appear early, during March. The main brood coming from the chrysalids at the clover do not appear until May. Last year (1892) much damage was done by these creatures.

One of the best remedies is to roll lightly the peas that are being eaten and then to dress the rows with soot and water, with a small quantity of paraffin oil mixed with it. The rolling reduces the ground to a fine state, if done when the land is dry, bruises many of the beetles and destroys their shelter, beneath rough clods in cold and windy weather.

The beetles should also be destroyed at harvest time when they are abundant, as is often seen in harvesting barley. They are sometimes thick in the carts and reapers, and can be swept off and burnt. Soluble phrenyl and water poured over the plants where the maggots are eating will kill them.

The Corn Weevil.

(*Calandra Granaria*)

This weevil attacks the corn chiefly when stored. It is about the same size as the ones described above and is of a testaceous colour, the snout being long and curved, with two elbowed antennæ arising from it. It is a native of India, but is now found in nearly all parts of the world. Samples of Indian, Australian, Russian, American and other wheats examined by the author were found to contain numbers of this pest, which commits terrible ravages in granaries and mills. The female beetle bores by means of her proboscis a minute hole in a grain of corn, and there places her egg. This hatches into a small creamy white maggot, which devours the endospermal part of the grain. It then turns to a pupa and sometimes in less than forty-three days it has passed through its changes and appears out of the grain as the perfect beetle. The eaten grain germinate just as well as the perfect ones. The presence of the maggot in the grain cannot be detected unless it is cut open. Much flour is composed of these squashed maggots, not to mention sundry meal worms and others that get ground up with them.

Amongst other destructive weevils the Raspberry Weevils (*Otiorhynchus sulcatus and picipes*), the Nut Weevil (*Curculio nucum*), the Apple-blossom Weevil (*Anthonomus pomorum*), the Clover Weevil (*Apion apricans*) and the Turnip Gall Weevil (*Ceutorhynchus sulcicollis*) may be mentioned, as attacking English crops.

The family *Bruchidae* (Fig. 20), with straight antennæ, has also destructive species, the worst being the 'Bean Beetles' (*B. granarius and pisi*) which live in their

maggot state inside the pea or the bean. Their presence can be told by a pale patch in the seed. All affected seed should be soaked in blue vitriol or carbolic gaswater, before it is sown, or else the larvæ will hatch and carry on the attack.

Fig. 20. Bruchus villosus, seminarius, pisi and larva (magnified).

Xylophaga.

This section includes a family of beetles that do much damage to the bark of trees. They are known as *Scolyti*. They are small black beetles, the larvæ forming long galleries under the bark. In many cases whole avenues of elm and other trees have been destroyed by them. *S. destructor*, a dark brown species with reddish legs and antennæ, is about $\frac{1}{8}$th of an inch long and is one of our worst tree pests, especially of the elm. The beetle forms a central gallery Fig. 22 (2) between the bark

Fig. 21. Scolytus destructor and larva.

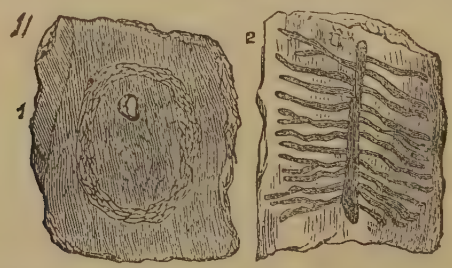

Fig. 22. Nest of Rhagium (1), and Burrow of Scolytus (2).

and the wood, and in this she deposits her eggs. The ova soon hatch into maggots which burrow tunnels at right

angles to the central cavity; the tunnels gradually getting larger. Pupation takes place at the end of the maggots' tunnel, usually near the outer part of the bark, so that when the beetle is hatched it has not far to bore its way into the open air. When many of these beetles have escaped the tree looks as if it had been riddled with shot, and death often ensues.

Never leave old and rotting trunks about, they form nurseries for this beetle. Barking the trees is most valuable, it causes an extra flow of sap and washes out the beetles and drowns the maggots, and it also leaves them exposed to the attack of birds and the cold.

Longicornia.

The *Longicornia* are one of the most elegant groups of beetles; they may usually be recognised by the very long antennæ, which are filiform, and by the tip of the abdomen in the female being produced into an ovipositor. The tarsi are 4-jointed. One of the largest beetles known, *Titanus Giganteus*, a native of Cayenne, is a member of this section. It is often $7\frac{1}{2}$ inches in length and 2 inches across the elytra. The colour is black, with the elytra and abdomen dark reddish brown. *Giganteus* is a member of the family *Prionidae* which have very large mandibles in the male and kidney-shaped eyes and a small and indistinct labrum. One of the most typical English Longicornia is the Musk Beetle (*Aromia Moschata*) belonging to the large family *Cerambycidae*, which, unlike the Prionidæ, have small mandibles, a well-marked labrum, and eyes, always concave, nearly surrounding the base of the antennæ. *Moschata* is the commonest of the large longicorns in North Europe. It is plentiful in England where willows abound and is seldom found far from them. The colour of

the Musk Beetle is rich green and looks as if powdered with gold dust, when examined with a lens; it has a lateral spine on the thorax and is about an inch and a quarter in length, with antennæ longer than the body. It emits an odour strongly resembling musk, hence its name.

The larvæ, which live in the wood of willow trees, are white, with the segments strongly marked, and burrow deep into the wood. The Wasp beetles (*Clyti*), black and yellow active creatures, also belong to this family. The third family, *Lamiidae*, is represented in England by one of the most curious longicorns *Acanthocinus Aedilis* or the 'Timber-man', as it is called in Scotland. The 'Timber-man' is a greyish-brown insect about half an inch long, with two more or less distinct dark bands, and may be found in the Pine Woods, especially in Scotland. The male is peculiar on account of its antennæ which sometimes reach four or five times the length of the body. The larvæ live in the wood; nearly all the Longicornia being wood borers.

Eupoda.

Of the group of beetles known as Eupoda a great many inhabit our Islands. It contains such terrible pests as the Colorado Beetle and the Turnip Flea. Many of its members although unknown to all but entomologists, are very beautiful creatures. All the Eupoda have short filiform antennæ, with, as a rule, 4-jointed tarsi, their bodies are very convex, round or oval; the hind femora is also characteristic, being very much thickened in the majority of species. There are several families, the *Chrysomelidae* being one of the most important. The *Chrysomelidae* have the head completely separated from

the thorax, which is transverse, the elytra being very convex, oval and nearly covering the body. The name comes from the Greek word *chrysomela* signifying a Golden Apple and is given to these beetles on account of the colours with which many of them are marked. One of the most beautiful species of the genus *Chrysomela* being found around the Llanberis mountains in Wales, namely, *C. Cerealis*. It is of a brilliant golden green, with a purplish lustre, three bands on the thorax and six on the elytra of a deep blue, bordered with green. It is found amongst the grass and stones on the mountain sides. To this family belongs the famous *Colorado-Beetle* known as *Leptinotarsa Decemlineata*.

The Colorado-Potato-Beetle is one-third of an inch in length, the elytra being marked with stripes of yellowish-brown and black. The thorax is dull yellow, with a distinct V-shaped mark on the centre and a few black dots on each side. The wings, strange to say, are red. The larvæ, which are such terribly destructive insects in America to potatoes, are reddish brown with black dots. It was only known for many years to feed upon the wild *Solanaceae* in the Rocky Mountains, but it spread to the settlements as they neared their natural home and found their food plant represented by the potato, one of the Solanaceæ. Such a supply of rich food caused a rapid increase, and now they are found over the whole of the United States and Canada. Prompt measures this side of the water stopped their introduction, and although it has several times been found in England, it has never succeeded in taking a firm hold and causing another disaster to our already too diseased potato crops. According to Prof. Riley, one of the greatest authorities on this subject, washing the plants, when attacked, with a dilute mixture of 'Paris Green' is the only remedy in case of attack.

This section also contains the family *Halticidae* or the family of Flea Beetles. The antennæ are long, cylindrical, and join the head, near together between the eyes; the hind legs are longer than the others and the hind femora thickened. They are all small oval or hemispherical beetles, often measuring less than $\frac{1}{12}$th of an inch in length. The Hop Flea (*Haltica concinna*) is very destructive at times in the Hop-gardens, but the turnip crops suffer most and we will consider this pest in greater detail.

The Turnip Flea (Phyllotreta nemorum).

The Turnip Fly or Flea Beetle is one of the most destructive insect pests we have. Turnip and all allied plants being attacked and often entirely destroyed by their ravages. *P. Nemorum*, one of the commonest of this group of pests, for there are many species, is oblong in shape and about $\frac{1}{12}$th of an inch in length; the elytra are shining black with a yellow stripe running down them in the middle, to the tip, where they curve round. The antennæ are 11-jointed and black, except the three basal joints which may be brown.

The femora are black, tibiæ reddish-yellow, the tarsi testaceous, tipped with black.

Two other species are found commonly with it, namely *P. Undulata*, which is smaller, and *P. Concinna*, which is brassy coloured and has a spine on the second and hind pair of tibiæ. Several others are found often in the same field with the three mentioned above. The beetles hop from leaf to leaf as you walk amongst the turnips, and are particularly active in hot weather and in bright sunshine. The cold seeming to have a bad effect upon them. The beetles themselves eat away large holes in the leafage, and when they attack young plant in large numbers often cause

complete destruction. They lay their eggs upon the under surface of the leaves, these soon hatch into small maggots, which burrow between the two layers of the leaf and form the tunnels so common in turnip leaves. Much harm is done also in this way, but by far the worst damage is caused by the adults attacking the young plant, which are unable to withstand this rough treatment. The larvæ only live six days and then they fall to the ground, bury themselves two inches beneath the soil and come up again as perfect beetles in about two weeks.

Many females hibernate throughout the winter. They also live upon Charlock, Jack-by-the-Hedge, and other weeds of the Cruciferous tribe.

The most important point is to stop their appearance, and this can only be done by destroying their natural food plants, Charlock especially, upon which they live before the turnips are up, and by the destruction of all rough places and grassy headlands around fields where they can hibernate and come out on the first warm Spring days to attack the Charlock and, later on, the turnip.

Secondly, the production of a fine and rich seed bed, so as to get the plant quickly through its young stages, where the chief damage is done. The application of superphosphates to an affected crop will often save it, by forcing it past the tender stages, as well as making the leaves objectionable to the Fly. Thick sowing of seed is also strongly recommended. The plant growing close together keeps in the moisture, and this is prejudicial to the beetle.

Thirdly, the application of some dressing when the beetles are present. Applications of dry dressings of lime and soot in the morning when the dew is on the leaf are found most advantageous. Paraffin spread by means of the strawsoniser over the crop when it makes its appearance above ground, was found most successful this year (1893) by

Miss Squire of Basmead Manor, Hunts: 1½ to 2 gallons of pure paraffin per acre was spread by the machine, with great success in saving crop.

Pseudotrimera.

The last section of the Coleoptera with which we deal contains the all-important family of Lady-Birds. The Pseudotrimera have generally 3-jointed tarsi and short antennæ. The Lady-bird serves as an example, and a fuller description of the section is therefore unnecessary. The tarsi are really composed of 4-joints. The microscope enables us to detect a fourth joint, namely the third, which is very small and concealed by the doubly-lobed second joint.

The *Coccinellidae* or Lady-birds comprise an extensive group of beetles, generally small and with a hemispherical body; the small, clavate, 11-jointed antennæ being concealed by the head when at rest. They are of very varied colours; most of the European species being either black with yellow or red spots, or yellow and red with black spots. Two of the commonest species in England are the 7-spotted Lady-bird (*C. 7-punctata*) and the 2-spotted Lady-bird (*Adalia bipunctata*). The former has a black head and thorax marked with creamy white, and seven black spots on the red elytra; the latter is smaller and has only one spot on each wing case, usually about ⅛th of an inch in length. They are extremely variable in appearance. The larvæ of the lady-birds are great friends to the farmer, as they live chiefly on Aphides or 'Dolphins' as they are called in Kent. The larvæ are active six-legged, black and slaty-grey creatures, marked often with orange and white, and may nearly always be found running about where Aphides are abundant. If they are watched they are seen

to devour the 'plant lice' very rapidly. They turn to pupæ, which are black and white, on the under surface of leaves. These larvæ of the Coccinellidæ are particularly useful in Hop-gardens, where they are greatly encouraged. French gardeners collect them and put them on their rose trees to clear the Aphides; they are called 'Vache â Dieu' or God's Cows, on account of the good they do.

CHAPTER V.

HYMENOPTERA

OR

ANTS, BEES, WASPS, SAW-FLIES, ETC.

General Account—*Hymenoptera-terebrantia*—Sawflies—Corn-Sawfly—Turnip-Sawfly—Gooseberry Sawfly—Pear Sawfly—Pine Sawfly—Wood Wasps (*Sirices*)—Gall Insects—Ichneumon Flies—*Hymenoptera-aculeata*—Ants—Fossorial-Hymenoptera—Anthrophila (Bees).

FEW insects have attracted more attention, from the earliest times, than the Hymenoptera. The bees alone have been the cause of this. "That they were cultivated by man in the earliest conditions of his existence, possibly whilst his yet limited family was still occupying the primitive cradle of the race at Hindoo Koosh, or on the fertile slopes of the Himalayas, or upon the more distant table-land or plateau of Thibet, or in the delicious vales of Cashmere, or wherever it might have been, somewhere widely away to the east of the Caspian Sea,—is a very probable supposition," say Shuckard. The earliest Semitic and Aryan records, the Book of Job, the Vedas, Egyptian sculptures and papyri, as well as the poems of Homer, give us ample evidence of the early cultivation of bees. From the study of the economic features of this order we soon find our way to the interesting side, and certainly, with the exception of the *Termites*, few insects can claim

such interesting and fascinating habits as the social hymenoptera, *viz.*, the Ants, the Bees, and the Wasps, and these have all received much careful study relating to their structure, habits and peculiarities. In recent years the hymenoptera have received another impetus to their study, owing to the injurious nature of one of the divisions, namely the Saw-flies. The Ichneumon flies, another family of this order, although of the utmost importance to us, and without whose aid as parasites we should be overrun with far more insect pests, have not received much attention. The Hymenoptera have four transparent membranous wings, with few veins, generally naked, but sometimes clothed with short hairs; the mouth is furnished with mandibles and also with a proboscis; the female has a conspicuous ovipositor, sometimes formed as a borer, in others modified into a saw, while the aculeate-hymenoptera have the ovipositor represented in the sting. The head is generally stoutly formed, and bears two large compound eyes and three ocelli on the forehead. They mostly have the abdomen attached to the thorax by a narrow waist. All the Hymenoptera undergo a complete metamorphosis. The larvæ are usually soft fleshy grubs, without any legs, but one group (the Saw-flies) has active larvæ, resembling the caterpillar of the Butterfly, but it has more fleshy legs; there are only ten in the Lepidoptera, but in the Saw-flies we get 16; they are known as 'false-caterpillars.' The pupæ are inactive and are usually swathed in a mantle or cocoon of silk. This order has the nervous system very highly developed, it consists of a large complicated brain, an infra-œsophageal and two thoracic ganglia and five to six ganglia in the abdomen. The Hymenoptera are primarily divided into two divisions, according to the use of the ovipositor. The first, known as the *Hymenoptera-terebrantia*,

has the ovipositor formed so as to use it as a borer, the second, the *Hymenoptera aculeata*, has the ovipositor modified into a sting.

Hymenoptera terebrantia.

This is the division containing the Saw-flies (*Tenthredinidae*), the Sirex or Wood Wasps (*Sirices*) the Gall Flies (*Cynipidae*), the Ichneumon Flies (*Ichneumonidae*) the Ruby-tailed flies (*Chrysididae*) and a few more unimportant families. The body of the above mentioned groups is not stalked; in the first two, which are known as *Phytophaga*, there is no petiole at all, the abdomen joins the thorax closely; in the remaining groups, which are known as *Entomophaga*, the abdomen is petiolated or at least attached to the thorax by only part of its base. The latter are either parasitic upon the eggs or larvæ of other insects or produce galls upon trees, the former (*Phytophaga*) live in their larvæ state upon vegetation.

Saw-flies.

(*Tenthredinidae*)

The saw-flies may be seen everywhere, in fields, woods, and gardens, often in great abundance. The female is always armed with the curious saw-like ovipositor, with which she cuts slits in the leaves and stems of plants, in which she carefully deposits her eggs, covering each one over with a glutinous secretion to keep it free from damp and moisture. This saw is a wonderful instrument,

Fig. 23 Sawfly (*Lophyrus pini*).

it is in the form of a double saw, with fifteen to twenty regularly placed teeth along the cutting edge, and these teeth are themselves toothed so that we get a double system of saws working at the same time. This double saw corresponds to the stylets of the sting of a bee; the two processes being fixed to the sides of the abdomen by a scale on either side. The perfect insects, which are often brightly coloured, do not eat much food; what they do consists of fruit. The larvæ, on the contrary, are very ravenous and often are very harmful to crops, especially turnip and fruit. They are often mistaken for the caterpillars of some butterfly or moth, but they are widely different and can readily be distinguished, by their number of sucker feet. The caterpillar of the moth has only five pairs, whilst these so-called 'false-caterpillars of the Saw-flies have always more, generally seven to eight. The larvæ moult several times and eventually turn to pupæ within a case or cocoon of silk or particles of earth. The cocoons are hardened by a glutinous saliva excreted by the larva, and may be found either upon the stems and leaves of plants or buried in the ground. As a rule the larvæ spin their cocoons in the autumn or late summer, but they do not change to pupæ until the spring. The *Tenthredinidae* are divided into several sub-families, according to the structure of the antennæ. The first sub-family, the *Cimbicinae*, has the antennæ short and knobbed at the end, like those of a butterfly. The Cimbicinæ are the largest saw-flies, they have a heavy flight and produce a loud buzzing noise. The larvæ which have eight pairs of legs have a tough-looking skin.

The sub-family *Hylotominae* is also an important one, in this the antennæ are only 3-jointed, the joints after the second being fused into one. In some genera the antennæ are bifurcated in the males. The sub-family

Tenthredinae have 9- to 14-jointed antennæ. The *Lydinae* have many jointed antennæ. In the *Lophyrinae* the antennæ of the males are doubly pectinated and feathery. The sub-family *Cephinae* have slender bodies and differ in general appearance from all the other Saw-flies, one of our well known corn pests belongs to this division, namely:

The Corn Saw-fly.

(*Cephus pygmaeus*).

The *Cephinae* are peculiar for many reasons, the larvæ, first of all, differ from those of most other saw-flies, for they live *inside* plants and have *no* fleshy legs. The adults are again peculiar on account of the compressed abdomen, which is knife shaped, whilst the antennæ are composed of twenty-one joints. The most abundant species is the black and yellow Corn Saw-fly (*pygmaeus*), which may be found in the corn fields, and on grasses in woods during the summer. The female cuts a slit, with her saw, in a stem of corn and deposits a single egg, this process goes on until about two hundred and fifty eggs are laid on separate plants. The ova hatch into white, fleshy, legless grubs, with a brown head and a pointed extensile tail, they work into the centre of the stem and there they eat their way through the hard nodes, either upwards or downwards. Shortly before the corn is ready to cut, the larvæ fall to the bottom of the straw which they have hollowed, and spin a cocoon, a little above ground level, where they remain through the winter. In the early summer they turn to the pupal state and are ready to emerge when the corn is coming into ear. It seldom appears in sufficient numbers in England to do much damage, but abroad it is a great pest.

There is only one practical way of destroying and checking the ravages of this pest, and that is by scarifying and harrowing together the stubble, after the crop is taken, and burning it. The larvæ are known to winter in the stubble and will thus be destroyed.

The Turnip Saw-fly.

(*Athalia spinarum*. **F.**)

Few insects can make such wholesale destruction of vegetation as saw-fly larvæ, and when plentiful few of these clear off the leafage of plants cleaner than do the 'Black Palmers' or 'Niggers', the larvæ of the Turnip Saw-fly. A turnip field stripped by these ravagers is a sight never to be forgotten; happily they do not often appear in any undue abundance. The Turnip Saw-fly appears in the early summer and is a very pretty insect, of a bright orange colour with black head and a deep reddish tint just behind it; the four transparent wings are orange towards the base and very shiny in the sunlight. The adults are torpid creatures in dull weather, and only fly about and copulate during the bright sunshine. The female lays her eggs in slits at the edge of the Turnip leaves. These ova usually hatch in about five days. The grubs are at first nearly white, but soon become green with a black head, later they become quite black with a pale stripe on each side of the body and with a white head; when full grown they become paler, of a slaty-grey colour with a black head. They have twenty-two feet in all. When full grown (in about three weeks) they may measure as much as $\frac{3}{4}$ths of an inch. They pupate in cocoons in the soil and in about twenty-three days the imago bursts forth and commences a new attack. Thus

there may be several broods in the year; the last larvæ remain in that condition in a cocoon throughout the winter. They feed upon Charlock and Wild Mustard as well as upon Turnips.

Sweeping the leaves with boughs of light leafage dislodges the 'Niggers', and if they are dislodged when changing their skins, which happens every five or six days, they are killed, as they are unable to fix themselves again to any object and thus cannot drag themselves from the old skin. Drenchings with liquid manure with some force, by means of a strawsoniser is found to be most beneficial, as the 'Palmers' are knocked off and destroyed in the wet soil.

The Currant and Gooseberry Saw-fly.

(*Nematus ribesii*).

This species is well-known to gardeners on account of the damage done by its larvæ to currant and gooseberry bushes; sometimes stripping them completely of their leaves. The imago appears in the spring and is about ½ inch in expanse of wings; the thorax and head are black marked with yellow, and the abdomen orange; the legs are yellow and black, and the wings irridescent. The eggs are laid in slits cut by the female around the edges of the leaves, from them hatch peculiar bluish-green coloured larvæ, with black spots on the segments and yellow markings on the head and tail. When full grown they pupate in earthen cocoons beneath the trees, where they remain as larvæ until the following spring.

Working gas-lime well into the soil, beneath the bushes, during winter or early spring, with a pronghoe, will destroy these larvæ; also dusting the plants when dew is on

the leafage with soot and lime or tobacco-powder. Removal and burning of a few inches of the surface soil beneath the trees after an attack, also does much good.

Pine Saw-fly.

(*Lophyrus pini*).

The Pine is attacked by two Saw-fly larvæ, *L. pini* (Fig. 23), being the most abundant. The caterpillars of this saw-fly feed upon the young leaves and bark. They appear in large communities. The Saw-flies hatch in April and July, when the female lays her eggs in slits cut in the pine leaves, which she covers with a resinous material. The larvæ hatch in about three weeks and like all other *Lophyri* have twenty-two feet. They are at first green with yellowish head and black suckers, when full grown there is a line of black dots along each side, the sucker feet become yellow and the head reddish-brown, and reach about one inch in length. In about two months they pupate in cocoons amongst the leaves or in moss beneath the trees. Sometimes the larvæ remain nearly a year unchanged in the cocoons. The male is black with pectinate antennæ, the female is whitish with black head, antennæ and pectus, and black marks on the thorax and abdomen. The wings of both sexes are beautifully irridescent.

Wood Wasps.

(*Sirices*).

The Wood Wasps or Sirex-flies have the ovipositor in the female formed for piercing the bark of trees, in the solid wood of which the larvæ feed. These flies are not

uncommon in fir plantations, where the larvæ burrow into and destroy the timber; they are large and conspicuous insects. *Sirex gigas* is a large species, the female is about an inch and a half long, black, banded with yellow on the first two abdominal rings, the last three segments also being the same colour; the legs are yellow and the wings brownish yellow. The male is smaller than the female, flatter and yellowish, except the first and last segments which are black, and the antennæ are longer than in the female. The white cylindrical maggots burrow into the pine trees and sometimes remain for a year, but are full grown in seven weeks, when they may change to pupæ. Another species, the Steel Blue (*S. juvencus*), is also found damaging the Pines in this country.

Gall Insects

or Cynipidae.

The curious swellings and rugosities seen upon the stems and leaves of various trees are due to the agency of certain insects. Some of these deformities are produced by small hymenopterous insects known as Gall Flies or *Cynipidae*, others are produced by small dipterous insects or Gall Gnats (*Cecidomyidae*), which are dealt with in a future chapter. The oak-apple is a familiar type of excrescence formed by one of the members of the former group. More than forty species of *Cynips* attack the oak. All the Cynipidæ are small flies, with a concealed ovipositor, which is sub-spiral, and their four transparent wings have few veins. They are found everywhere in spring and summer. The female deposits her egg or eggs in a small hole bored by the ovipositor, and at the same time ejects an irritating fluid into the wound, which sets up an extra

flow of sap to the damaged spot and produces the abnormal growth. The ova turn to maggots inside the galls where they live and assume the pupal state. Some very curious structures are produced by these creatures, such as the curious red mossy excrescences called 'bedeguar' on the wild rose, the gall of *Rhodites Rosae*. The so-called Apples of Sodom found near the Red Sea and the important 'gall-nut' of commerce, from which ink is formed, are also their work. The Cynipidæ present many interesting problems. It is now a well-established fact that most of the Cynipidæ are dimorphic and exhibit a regular alternation of generations, the spring and autumn broods being so entirely different that they were considered different genera. The spring brood consists wholly of fertile females and the autumn brood of males and females. The galls from which the two broods spring are also often quite different. The spring females often produce young parthenogenetically.

Ichneumon Flies.

(*Ichneumonidae and Braconidae*).

The *Ichneumonidae* and *Braconidae* form together two closely allied families, both in characters and habits. They are extremely numerous, more than 10,000 species having been described. They vary considerably in size, some exotic species reaching large dimensions, others being very minute insects. They are the great agency by which the balance of insect life is kept up and restored, when once upset; for these Ichneumon flies are parasites upon other insects. There are several other families, also parasitic, related to these (*Chalcididae*, *Proctotrypidae*, *Evanidae*). The Ichneumon flies have, as a rule, a long

thin body, which is terminated in the female in a long ovipositor. The latter structure is very variable in these parasitic insects, which lay their eggs in other insects, buried either in the ground or in a tree. We find the egg-laying tube in the above very long. Those that lay their ova directly in the insect have it short, but it is always present as a sharp piercing organ. These curious and important parasites lay their eggs not only in the larvæ of other insects, but in their eggs also. The female Ichneumon may lay only one or maybe fifty or sixty ova in the body of one caterpillar. These ova hatch into small white grubs, that continue feeding upon the fatty tissue and juices of the victim, but do not kill it until the time has been reached for the metamorphosis to take place. Many a collector of butterflies and moths has been disappointed in finding some beautiful larva sicken and die just at its time for pupation, and to see from its dead body a number of small yellow silken cocoons appear, the cocoons of the parasites that have gradually destroyed it, but not until they themselves were fully formed. It is a very usual sight to see the skins of the Cabbage White Butterfly sticking to a fence, surrounded by the yellow cases of the Ichneumons that have caused its death. To these parasites we owe a deep gratitude, for they keep down our pests,

Fig. 24. Ichneumon (Bracon bicolour).

and without them we should have far more reason to complain than we have now. Amongst the *Braconidae*, (which have the 2nd and 3rd joints of the abdomen united together and the first three segments larger than the other), we find the important genus *Aphidium*, which, with other allied genera, attack the 'Plant Lice' and destroy them by thousands. The important genus *Microgaster*, which destroys the Cabbage White Butterfly also belongs to this family. Whilst amongst the other families we find hundreds of species each doing its good work in keeping down an excess of any one species. There is no doubt that the Hessian Fly has become scarce in England through the increase of the numerous ichneumons that prey upon it, in its oval and larval stages.

Hymenoptera Aculeata.

The aculeate hymenoptera are those that are armed with a *sting*, instead of an ovipositor. They contain the interesting Ants, Bees, and Wasps, groups which have given rise to so much general interest; they are only dealt with in a cursory manner here, so much having previously been written on them. These stinging hymenoptera contain seventeen families, the first of which is the *Formicidae* or Ants.

Ants

or Formicidae.

Few insects can boast of having received so much attention as the ones in question, and rightly too, for nowhere in the insect world do we find such wonderful habits, variations and instinct as amongst these social insects. As far as we know all ants live in communities of various size, and each community is composed of three distinct

castes, the male and female and the worker; a fourth caste may be present as soldiers, for the protection of the community. The workers are the ones we most often see, they are wingless forms; the males and females only appear outside the nests at certain times of the year, when they swarm out and fly about in the air, both sexes having four large, delicate membranous wings. Soon their flight is over and the female has her wings roughly torn off by the male, and then they commence to form fresh colonies. Large numbers of eggs are laid by one female. The Formicidæ are divided into three sub-families: (i) the *Formicinae* which bite fiercely but are stingless, (ii) the *Ponerinae*, in which the females and workers are armed with sharp stings, and the petiole of the abdomen is formed of

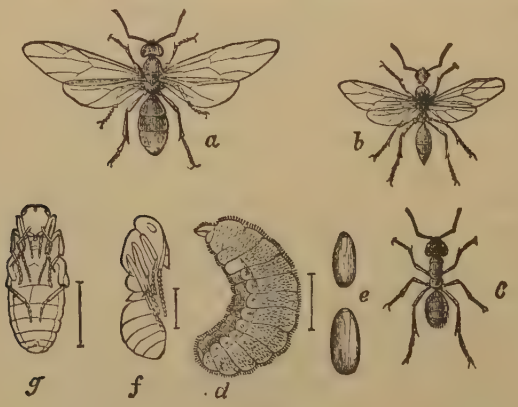

Fig. 25.

Ants. *Formica herculanea*. *a* = female, *b* = male, *c* = worker, *d* = larva of *F. rufa*, *e* = pupa in case, *f* and *g* = free pupa.

one knob, and (iii) the *Myrmicinae*, which also have stings, but the petiole of the abdomen is formed of two knobs. One of our most easily observed ants is the Common Red Ant (*Formica rufa*), common in many woods,

especially pine woods, in England and very abundant on the Continent. The workers of this species are nearly red and have a black spot on the head and thorax, whilst the abdomen is reddish black above, except at the waist. The female has the same general appearance as the worker but is very shiny, and the upper part of the head, thorax and abdomen are black. The male is larger than the female and is entirely black and hairy. These red ants which may be seen so busily engaged in running about in woods, build large dome-shaped nests, which cannot fail to attract one's attention. If we examine one of these we shall see it is composed of pieces of stick—pine needles being a favourite material—stones, earth, and various odds and ends. On breaking down part of the nest, the ants swarm out in all directions, but we shall notice they never seem to lose their presence of mind, each seems to know its work, even when such a disaster happens. Some run off with the pupæ and larvæ in their mouths, carrying them deeper into the recesses of the nest, away from all harm; others commence at once clearing away the debris, whilst their companions set to work to make good the damage. While they are doing this the observer has time to see that this rough looking lump of earth and rubbish, is arranged upon a definite plan. The whole nest is interlaced by galleries, tier upon tier, and larger chambers in which the larvæ and pupæ are kept and nursed by the worker ants. These galleries communicate with the exterior by apertures at the top and sides of the nest, which are always closed up by the ants at night and during rainy weather.

One of the most curious habits of ants is that of harvesting grain; this was long disputed, but is now well known and is seen to be a constant habit in some foreign species. All the true harvesting ants seem to belong to

the genus *Atta*, which have two forms of workers. *A. Barbara*, a black ant with red head, and *A. Structor*, a reddish-brown species, are two well known insects, common around the Mediterranean. They store up all manner of seeds for food, even cleaning them of the husks, which they throw away. More curious than this is the so-called Agricultural Ant of Texas (*Pogonomyrmex Barbatus*), a reddish-brown species about half an inch long. The nest of this ant is placed in a sunny spot, and the grass and weeds are cleared away for a distance of ten or more feet around it by the ants, and this space is even covered with pebbles, upon which no weeds are allowed to grow, and from this they form roads 2 to 2¼ inches wide and thirty or more feet in length in various directions, cleared of all weeds and obstructions. Along these tracts the ants go and bring their harvest of seeds, husking them before they are stored. It is even said this species grows and harvests near the ant hill, a particular kind of grass the seeds of which are its favourites. That ants make raids and capture slaves from other species is also well known; these slaves being made to do the work of the community; and that they bury their dead in definite places M'Cook has clearly shewn. Some species are migratory in their habits, migrating in vast armies and driving all other insects before them as they advance; entering houses as they go and clearing off all vermin, not even rats and mice escape them. When they approach a stream, they form a bridge of their own bodies, clinging to one another, and so pass over. The migratory habits are best seen in the genus *Dorylus* in Africa and America. It is not possible to enter into a further account of these interesting creatures here, as space will not permit. The reader is referred to Sir John Lubbock's work on *Ants, Bees, and Wasps* for further interesting details.

Fossorial Hymenoptera.

The so-called Solitary Ants (*Mutillidae*) belong to a different family. They are parasitic and frequent the nests of humble-bees. The females are apterous, but armed with a sting. They are covered with down and are usually black or dark blue, with red thorax and with abdomen adorned with white, yellow, or red.

The *Sphegidae* have several peculiarities; the abdomen has a long round petiole, consisting of the first and sometimes part of the second segment. In shape they somewhat resemble Wasps, but the latter have the sides of the prothorax prolonged backwards to the base of the wings. They provision their nests with insects and spiders; attacking kinds much larger than themselves, such as cockroaches and grasshoppers. They do not kill them, but paralyse them, by stinging the central nervous system, and then drag them back to their nest and so provision it with living but helpless food, ready for their young when they appear as maggots from the eggs. The *Pompilidae*, an extensive family with long legs and oval abdomen attached to thorax by a short petiole, black in colour, with red legs and abdomen, especially at the base, also hunt for spiders to provision their nests. The English *Pompilidae* form their abodes either in sand banks or in rotten wood.

Diploptera = Sand-wasps and Wasps.

The Solitary or Sand-Wasps, *Eumenidae*, build their nests in mud and sandbanks, which they provision with insects. The cells or nests have generally a tubular entrance, projecting from the mouth. The chief genus is *Odynerus*, found all over the world, several of these black and yellow sand-wasps being found in England.

The true wasps or *Vespidae* are social in their habits; males, females and workers being found. The workers are really females, which never lay eggs, they are provided with wings, yet differ considerably from the perfect females. Those social wasps form nests of a papery substance. The communities only lasting for one year; at the approach of cold weather the males and workers die off and only the females remain to hibernate until the following spring. The female as soon as she comes out of her winter retreat in the spring, commences to form a small nest and to lay an egg in each cell. As soon as the maggots are born, the female commences to get food for them and thus the maggots grow rapidly and soon mature and spin a silken cocoon, in which they pupate. The nymphs so formed soon give rise to the adults, which are all workers. These at once commence taking on the duties of the nest and the female or queen leads henceforth an idle life. Later, some of the pupæ turn into fertile females and thus start fresh colonies. The papery substance of the nest is made from triturated wood fibres and leaves, mixed with saliva and then moulded into a kind of paste, and smeared into the thin laminæ of the nests. The larvæ are feeble maggots, but they have large and strong mouths. The Bush Wasp (*Vespa Sylvestris*) is one of our commonest species. It forms its nests on the branches and twigs of trees, under roofs and in bee hives. The nests are delicate round structures, composed of a thin papery tissue, with a thick column inside, sustaining the comb, which is composed of about twelve cells at first. The comb is gradually increased by the workers, until the nest may reach a foot in height. The opening is placed at the bottom of the nest. Our Common Wasp (*V. vulgaris*), builds its nest in the ground, they also have several papery envelopes and

assume sometimes large dimensions, containing thousands of workers. One of the largest of the Vespidæ in England is the Hornet (*V. crabro*), which has a reddish head and thorax. The Hornet makes its nest in the hollow trunks of trees and in the roofs of houses. The upper part of the comb is attached to the starting point by a mass of wax, made up into a spiral column; the second and following combs are attached beneath the first, and united to it by little columns. The whole is covered by a yellowish-brown papery envelope, made from rotten wood.

Other genera of Wasps are found in different parts of the world; the genus *Polistes* has the body elongated and the first segment formed into a short pedicle. They attach their open nests to low plants, and can be watched feeding their young with ease. The sting of the wasp is only too well known and produces considerable pain. They are often toothed along each side and have been known to lead to serious results, when a person is in a bad state of health. In the early part of the year the wasps live upon insects, but in the latter part upon fruit.

Bees.

(*Anthrophila*).

All the sexes have wings and the females are armed with a sting, their antennæ being 12-jointed, while in the male they are 13-jointed. All the bees have a very high organization; the nervous system is more concentrated than in any other group of insects, whilst their tracheal system has unusual features, the main tracheæ being swollen out into larger air sacs, which are used for buoyancy when the bees are flying. The mouth parts also undergo various modifications, some have the mandibles formed into pincers for cutting through wood, or for digging their nests in the earth, to knead the

cement for their nests and to form wax. The jaws and the lower lip are usually formed into a sucking tube to take up nectar from the flowers. The bees are all vegetable feeders and form their nests in the ground, some are solitary, others social. The social bees have the three 'castes,' the male, fertile female, and worker or sterile female (Fig. 26); the solitary bees have no workers. There is also a third group, the parasitic bees, or those that live in the nests and at the expense of others. The larvæ of the Anthrophila are all legless grubs, incapable of looking after themselves. They spend their life in the narrow cells and there turn to pupæ; they are cared for and fed by the adults, their food consisting of a kind of cake kneaded from pollen and honey. The *Andrenae* are perhaps one of the most important of our genera of bees; they are all of fair size and form a large proportion of those bees we see in the spring, flying from flower to flower. They are solitary, not social, although we find they form their tubular nests in the ground or sandbanks near one another. Their tunnels are simple tubes, they vary from 3 to 7 inches, and may in some species have smaller tunnels passing off at right angles to the central one. When these little cells are formed they are stocked with honey and pollen and the aperture closed up with sand. These Andrenæ collect large quantities of pollen, sometimes masses being attached to their legs as big as their heads; to do this they have besides the ordinary instrument for holding it, a long lock of hair springing from the posterior trochanters. The larvæ of these bees do not spin a cocoon, but the pupae are covered with a delicate skin which adheres closely to all parts of the body. The Andrenae are pretty bees, often densely covered with hair, but sometimes almost naked. They are usually brown and reddish-brown in colour, but some

have purplish and white tints and others are covered by a red pubescence. The males have often large square heads, broader than the thorax, and are often very different to the females. The genus *Halictus* is another large and important one in this country. The *Halicti* are mostly small bees, the males being very unlike the females, having a long cylindrical body. They are gregarious and nest together in great numbers, although some are solitary. These little bees often are very pretty objects, of a metallic green or blue, with bands of paler colour, and sometimes with reddish-brown pubescence. They form tunnels, which branch off into several cells, in banks; the tunnels are smooth inside and covered with a glaze when complete. It appears they only form them during the night and in the day they fill them with the food for the young. On the first warm days of spring it is not unusual to see a large brilliant yellowish-brown bee hovering over the Croci and other spring flowers and to see it pursued by one of similar form only black; these are representatives of the genus *Anthophora*.

This genus has two distinct sections. *A. retusa*, the commoner of the two species, tunnels into sand banks, where they form elliptical cells, lined by a white membrane, formed by a secretion derived from the digestion of the pollen or honey. This species may be found in colonies of several hundreds. The second section has the male and female the same colour, and no elongated tufts on the middle tarsi. They are solitary; one species burrowing alone in some sand bank (*A. acervorum*), the other tunnels into putrescent wood. The Cuckoo Bees (*Nomada*) are true parasites. They are the gayest of all our bees, being banded with yellow, red and black. They emit the most pleasant balmy odour when caught or disturbed. Their eggs are laid in the nests of various

Andrenæ and other bees; some kinds being restricted to a certain host, others attacking various species. The most interesting structures formed by bees are the nests of the Leaf-Cutting Bee (*Megachile*). The Leaf-cutters have long mandibles with four teeth in them. They are remarkable looking insects, somewhat smaller than hive bees, as a rule; black in colour, with reddish hairs on the thorax and white down upon the head. They burrow into the ground and line the tunnels with pieces of rose and other leaves, cut as clearly out as if cut with scissors and united together, forming an inner tube within the tunnel, which becomes so firm that it can be taken from the earth or wood and remain whole. Each tube is made up of several cells, in which the larvæ are placed singly with some food. It is a very interesting sight to watch these bees cutting and carrying off the pieces of leaves. *M. Centuncularis*, the type of the genus, burrows in decaying wood and walls as well as the ground and uses the leaves of the Mercury (*Mercurialis annua*) as well as those of the rose for its nest. The author found one under the sill of

Fig. 26. Drone, Queen and Worker of *Apis mellifica*.

a window in a drawing-room, the bees entering through a ventilator when the windows were shut. The different species seem to prefer different plants to line their nests with. When full fed the larvæ spin a cocoon of silk, which is united to the sides of the cell. The Humble Bees (*Bombi*) are the most conspicuous of our native bees,

they are known as 'bumble bees,' 'dumbledors,' and 'foggies.' They are large hairy bees and consist of males, females, and workers. All the Bombi are social in their habits. The females are very large, the workers small. These and *Apis Mellifica* are our only social bees, that live in governed communities. The management of the nests of the Bombi is very inferior to that of the hive bee. The females which hibernate appear in the spring and commence the brood for the year. They form nests in the ground resembling the nest of a field mouse, and have even been known to use the nest of a bird. The first eggs laid by the hibernating female give rise to workers, and then the community is got in proper working order. The Bombi are subject to the intrusion of another group of bees, the *Apathi*. These parasitic Apathi are like the Bombi in appearance, but as they do no work there are no workers, males and females only being found; they lay their eggs in the nests of the Bombi and the workers of the latter feed their larvæ. The legs of the Apathi are not formed for collecting pollen, as are those of the Bombi. Last but not least must be mentioned the hive bees (*Apis Mellifica*), which are now cultivated nearly all over the world. They have the highest organization of all the hymenoptera, except the Ants, which far surpass the bees in instinct. They live, as is well known, in a highly organized community, governed by a single female or queen, each community consisting often of thousands of individuals, the males or drones only appearing at certain times and doing no work. Nearly every work on Natural History treats fully of these insects and as so much has already been written, we may be allowed to pass over these interesting and extremely useful and *paying* social insects, without further comment.

CHAPTER VI.

LEPIDOPTERA OR BUTTERFLIES AND MOTHS.

General characters—Larvæ—Pupæ—Scales and Coloration—Rhopalocera—The Cabbage-Whites (*Pieridae*)—Heterocera—Sphinges—Bombyces—Noctuæ—Geometræ—Currant Moth—Winter Moth—Pyrales—Crambi—Tortrices—The Codlin Moth—The Tineæ—The Diamond-back Moth—Pterophori and Alucitæ.

THE Butterflies and Moths or *Lepidoptera* form an order easily recognised, very few of its members having the characters of other insects. Some might, however, be confused with the Caddis Flies (*Trichoptera*), and a few moths have certainly strong resemblances to the Hymenoptera. As a whole, however, the order is so clearly defined that no mistakes can occur as to the proper position of a butterfly or a moth. They are distinguished by the following important characters. The mouth is suctorial, and consists of a spiral proboscis or 'antlia' as it is sometimes called; this antlia is composed of the maxillæ, greatly elongated, and protected when at rest by the large hairy labial palpi; the maxillæ form two sub-cylindrical tubes, united together and constituting an intermediate tube by their junction; the remaining parts of the mouth are rudimentary, namely the mandibles and labrum; the maxillary palpi being present as very minute bodies. The wings are four in number, they are flat membranous expansions, covered

with scales. The veins of the wings are not very numerous and are mostly longitudinal. Besides scales the body is often covered with hair. The two antennæ are composed of a number of small joints, and are very variable in form, in the true Butterflies they are always clubbed at the apex, in the moths they are never clubbed, but may be thread-like, pectinated or feathery. There are about 50,000 species found in the world and no doubt this number will be doubled when we have searched the more remote parts for the smaller species. The Diurnal Lepidoptera or Butterflies have naturally been sought after in most parts of the globe on account of their beautiful coloration; many of the finest and most brilliant species, especially the beautiful blue Morphios, are only found in the most inaccessible places, and although well known are extremely rare and demand great prices. A large amount of destruction is caused by certain members of this order and these unfortunately are very difficult to cope with, their attacks luckily are not persistent, they come by 'fits and starts' as seen in the destructive 'Diamond-back-Moth', which ruined so many acres of turnips in 1891. Amongst the Butterflies in England only the Whites (*Pieridae*) or Cabbage Butterflies ever commit any serious havoc, but in the Noctural Lepidoptera we find many injurious species.

Larvæ or Caterpillars.

The Caterpillars or Larvæ of the Lepidoptera are hatched from beautifully sculptured eggs, laid by the female insect. As a rule the small amount of instinct shewn by the female butterfly, is exhibited in her choice of situation for the deposition of her eggs, which she invariably places near the plant upon which the larvæ feed. The 'cat-

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pillars' are, as a rule, vermiform in shape and composed of thirteen segments; the head is horny and has the mouth armed with hard biting mouth parts, and with 'spinnerets' on the labium for the production of the silk, used by many in forming the silken cocoon in which the pupal stage takes place (moths), or for forming the caudal attachment in the butterflies. The first three segments of the caterpillar represent the pro-, meso-, and metathorax,

Fig. 27. Larva (1) and Pupa (2) of Eyed Hawk Moth (*Smerinthus ocellatus*).

and each bears on the ventral surface a pair of jointed horny legs.

Behind these follow the abdominal segments which bear other legs, fleshy protuberances of the body, called *prolegs*. These prolegs are, as a rule, ten in number; they are never attached to the 1st, 2nd, 7th, and 8th abdominal seg-

ments. They are armed at their base with a circlet of hooks, very prominent in some larvæ. The coloration of caterpillars is very variable, and each species is subject to great individual variation. The hairy species are usually brilliantly coloured, the smooth-skinned kinds are generally brown or green, depending upon, to a great extent, their rendezvous. There is little doubt that the caterpillars of the Lepidoptera adapt themselves to their surroundings, for the purpose of protection against the prying eyes of birds. Many larvæ after having attained their full size, spin a cocoon in which they assume the pupal stage, others only spin a silken attachment at the tail end and turn into a naked 'chrysalis' as in all butterflies. All the larvæ of Lepidoptera are vegetable feeders, some living within the leaves (miners), others devouring the entire leaf, and a few living in the interior of the wood itself.

The Pupæ or Chrysalids.

The quiescent period of the Lepidoptera, the chrysalid or the pupa, the period when the mandibulate larva is transformed into the haustellate perfect insect, takes place in very varied places. Most of the butterflies as described above have their chrysalids naked, *i.e.* with no cocoon; the moths may pass this stage in the ground in a case of earth, in a cocoon of silk, in wood, amongst leaves or quite naked in the soil. The period of pupal life is very variable, in some species lasting only two weeks, in others a whole year or more. The pupal cases are usually of a dull colour, some brown, others black, a few, as the Currant moth (*Abraxas*), have them banded with yellow. Those of the Butterflies are often more brightly coloured, greys and whites, spangled with gold and silver, being the dominant types.

Scales and Coloration.

The scales of Lepidoptera are very beautiful structures. As a rule they entirely cover the wings, but in certain butterflies the scales are only few in number, and situated around the edges and veins. Scales are modified hairs and assume a variety of forms. They are thin membranous plates with a small stem which fits into a cavity in the membrane of the wing. The scales are present on both sides of the wings. Each scale is composed of two layers, the outer surface being corrugated; there also appears to be a thin middle membrane. The scales are the colouring elements of the wings. The colours are produced by extremely small dots, beads and corrugations, which act upon the rays of light and produce the phenomena of interference. There is also colouring pigment in the scales, but most of the effect is brought about by the 'interference' and decomposition of light.

The colours produced by these scales are of every possible shade, the most uncomplimentary tints seemingly fitting together under the touch of nature. The northern insects are not remarkable for their colours, the majority being of dingy shades, certainly yellow and blue are represented rather brilliantly, but when we compare the butterflies and moths of the north of Europe with those from the south, we see a marked increase of bright colours in the southern forms; as we approach the tropics we find their brilliancy steadily increasing, the most gorgeously coloured species and genera being found in and around the tropical regions. The colour in some species is subject to considerable 'variation'.

The Lepidoptera are divided into two great sections, the *Rhopalocera* or Diurnal Lepidoptera (Fig. 29), that is butterflies, and the *Heterocera*, or moths. The former section is

characterised by the antennæ being clubbed at the tip and by the forewings being separate from the posterior pair during flight. The moths have the antennæ variously formed, not clubbed, and often have the forewings hooked by a bristle to the posterior pair in flight. They are mostly crepuscular or nocturnal.

The Rhopalocera or Butterflies.

The Diurnal Lepidoptera are divided into five families. The first the *Nymphalidae* which is by far the largest of the five, is divided into a number of sub-families, and includes the Ringlets, Graylings, the beautiful blue South American Morphios, the tropical American Heliconias, the Fritillaries, the Tortoise-shells, Red Admirals, Purple Emperor and the 'Heath' Butterflies.

The Nymphalidæ are all characterised by the front pair of legs being more or less rudimentary and by the pupæ only being attached by a silken mass at the tail end.

The first sub-family or the *Danainae* is only represented in Europe by one species, *Danaus Chrysippus*, a fawny species with black and white markings. It has been taken a few times in England and is our largest English Butterfly. The male has on the hind wing a raised patch of scales which are supposed to form a scent-producing organ. The typical Danaidæ or 'Spectre Butterflies' are inhabitants of Asia and Africa. The wings are rounded and scalloped, but never ocellated. The larvæ are not spiny, but are furnished with long fleshy tubercles.

The Grayling Butterfly which we so often see on dry and heathy places, and on rocky spots along our sea shores, is a member of the next sub-family *Satyrinae*. The Satyrinæ have also rounded and scalloped wings, occasionally tailed, but nearly always ocellated. They are

generally moderate sized species with dull colours and as we should expect, very many are found in Europe, nearly a third of the known species. Many of the genera are confined to mountainous regions; the genus *Maniola* or the 'Mountain Ringlets' being one of the mountainous groups; although a few species are found in low ground, only two species of this genus are found in our Islands, both in the north. The pale tawny genus *Aeneis* with marginal spots is almost exclusively confined to the arctic regions, only one or two being found elsewhere (in the Alps). In S. America we find members of this sub-family with nearly transparent wings (*Lithaerias*, etc.). The *Morphinae*, the sub-family to which those gorgeous blue butterflies (*M. Rethenor*) of the Amazon belong, are not met with in Europe.

The Fritillaries (*Argynnis*) are a typical European genus; they belong to a large sub-family called the *Nymphalinae*. These 'Fritillaries' which are found also in Asia and North America are always fulvous, with black spots and borders, with numerous and varied silvery spots and marks on the under surface of the hind wings. Some of the smallest species extend to the arctic regions, but they do not so far appear to be found south of the Sahara, in Africa.

To this sub-family also belongs the important genus of *Vanessa*, our Painted Lady, Tortoise-shell, Red Admiral, etc., so often seen in our gardens in autumn and occasionally appearing in great numbers, but as they chiefly feed on nettles and other common weeds they do no damage.

Amongst this large division of Butterflies are placed our beautiful 'Purple Emperor' and 'White Admiral' and many others.

The second family of the *Lewoniidae* have the front pair of legs rudimentary in the male and fully developed

in the female. They are all small insects, our 'Duke of Bungundy Fritillary' (*Nemeobius Lucina*) is the commonest European type.

All lovers of nature in the country are well acquainted with our beautiful little blue butterflies; we can take these to represent the third family of Rhopalocera. This family is known as the *Lycaenidae* and they are distinguished by the perfect front legs in the female and by the more or less imperfect tarsi in the male; their pupæ which we often find on grass and low growing herbs have, besides the caudal fixture, a belt of silk around the body. To this family also belong these beautiful little butterflies, seen on heaths, known as 'Coppers'. The genus *Thecla* or the 'Hair streaks', a very extensive group also belongs to this family. The Purple and Brown-Hair-streaks belong, however, to another allied genus, *Zephyrus*. Tailed Lycænidæ are also abundant in Africa and the East Indies.

Fig. 28. *Pieris brassicae*, Large Cabbage White.

The fourth family, the *Papilionidae*, is the most important to us as it contains the destructive group of the 'White Butterflies'. The Papilionidæ have all six legs perfect and their larvæ are long and cylindrical, but not spiny and the pupæ have a silk belt as well as a caudal fastening. There are two large and important groups, the

Pierinae or 'Whites' and the *Papilioninae* or 'Swallow-tails'. The former have the inner margin of the wing not concave. The prevailing colours are white and yellow. The genus *Pieris*, (the Cabbage Whites) is the most important, as they often destroy our cruciferous crops to an alarming extent, and we append a fuller description of the large Cabbage White (*P. Brassicae*), one of the worst pests in its larval state. (Fig. 28).

Large Cabbage White.

(*P. Brassicae*).

The forewings of this species are creamy white with a broad black patch at the tip in the male, in the female there are also two black spots in the middle of the wings. The underside of the front wings of both male and female is white with two black spots; the posterior are pale yellow, with a fine dusting of black. This butterfly appears first in the spring and then later in the summer. It lays its eggs upon the under surface of cruciferous plants, chiefly of the Cabbage tribe (*Brassica*); the eggs are yellow in colour and laid in clusters of twenty or thirty; from these ova hatch caterpillars, which are greenish at first, they then become bluish green above, yellowish below, with a yellow line along the back and at each side and spotted with black, and covered with pale hairs. These larvæ devour the leaves of cabbages, mustard, and turnip very ravenously, and in certain years do much damage, especially to thousand-headed-kale. When full-fed they crawl off to some sheltered wall or fence and there turn to the chrysalis state. The chrysalis is pale green spotted with black, attached by the tail and by a silken cord around the body.

The most practical way of checking this pest the author knows of that can be adopted in gardens, is by drenching the affected plants with soap-suds. This effectually gets rid of the caterpillars. Soot and lime dusted over the plants also disperses them, but on a large scale no method is satisfactory.

Cabbage being required for food, one cannot use any pungent or poisonous agents if they are in an advanced stage of growth.

Luckily for us the larvæ of this butterfly are subject to a very deadly enemy, in the form of a parasitic hymenopteron, an ichneumon fly, scientifically known as *Microgaster Glomeratus*. This parasite attacks the larvæ. The eggs are laid in the caterpillar's body and soon turn to maggots which live upon the internal organs, but do not destroy them until the time comes for the larvæ to assume the pupal stage. One often notices the skins of these creatures on a wall or fence, surrounded or covered with a mass of little yellow silken cocoons. These cocoons are formed by the maggots within the larvæ and give rise to many ichneumon flies.

Another species *Pteromalus brassicae* attacks the chrysalis and destroys it in a similar way. They always appear in great numbers when the 'Whites' themselves are abundant, and usually the following year the Lepidopterous pest has greatly decreased. These little yellow cocoons of the parasites should always be carefully preserved, as they form one of the safest ways of getting rid of these destructive larvæ.

The Small White (*P. rapae*) and the Green-Veined White (*P. napi*) work in a similar way, but their eggs are laid singly. The larvæ of the Small White are often called the 'Heart-Worm' on account of the green caterpillars feeding in the heart of the Cabbages.

The Clouded-Yellow (*Colias Edusa*), an orange species

with black borders to the wings, with black spots in the female, also belongs to this family. *C. Edusa*, which often appears in great numbers, has occasionally been recorded as doing damage to the clover crops. Although often common it seldom appears in sufficient numbers to do any appreciable amount of damage, necessitating special methods for destroying the larvæ.

Those who have frequented the 'Fens' of Cambridgeshire may be acquainted with our only representative of the true Swallow-tails, *Papilioninae*, in the beautiful Swallow-tail Butterfly (*Papilio machaon*). This sub-family has the inner margin of the hind wings concave. It also includes those beautiful large Bird Butterflies (*Ornithoptera*) from the East Indies, sometimes reaching nine inches in expanse of wings. The males have the front wings velvety black and the posterior wings a brilliant green, while the same genus in Ceylon and the Indian Peninsular have the hind wings a brilliant orange. Another elegant genus is *Parnassius*, including the Apollo Butterflies of the Alps and Norway.

The last family of the Rhopalocera might easily be mistaken for moths. This family is known as the *Hesperiidae* or 'Skippers'. They all have a robust body and a broad head, antennæ often hooked at the tips and with spurs on their hind tibiæ. They present little or no affinity to the other butterflies and no more to the true moths. They are especially abundant in tropical America, but scantily represented in Europe. Several species, all of a dingy appearance, are found in our own Islands, darting about heathy places and commons.

Heterocera or 'Moths'.

The moths are far more abundant than the butterflies and unfortunately they do a very great deal of harm to

root and garden crops and also to stored grain. A few only of the more important families (especially those that contain destructive species) can be described here.

Sphinges.

The largest and handsomest of our moths are the *Sphingidae* or Hawk-Moths. They have large stout bodies. Their larvæ have generally a horn near the tail (Fig. 27). The heavy Death's-Head-Moth (*Acherontia atropos*) (Fig. 29), whose large green caterpillars with purple stripes on each side are often found on the potato, belongs to one section of this family. While the rapid flying Humming-Bird Hawk

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Fig. 29. Death's-Head Moth. *Acherontia atropos.*

(*Macroglossa stellatarum*) seen on warm days hovering like a humming bird and thrusting its long proboscis into some flower, belongs to another group.

Bombyces.

The family *Liparidae* to which belong the well known tawny-brown Vapourer Moth (*Orgyia Antiqua*), the female

of which is devoid of wings, is a plentiful group in Europe. Many of these Liparidæ have the habit of appearing in large numbers in certain years. The 'Vapourer' mentioned above occasionally appears in great abundance, and causes much damage to the fruit trees as well as disfiguring the hawthorn hedges. The females of these moths are always much larger than the males, both in expanse of wings when present and in the size of the body. The Gipsy Moth (*Liparis dispar*), which is brown in the male, but white with black markings on the forewings in the female, seems to take the place of our Vapourer Moth on the Continent, where its larvæ do much damage to the apple and other fruit trees. A curious little family, the *Psychidae*, are related to the one just described. The larvæ of this group have a curious habit of forming cases, or houses, such as we see in the 'Caddis Flies'. The females of these Psychidæ are without wings, neither have they any antennæ, whilst their legs are rudimentary.

The female is really a helpless bag of eggs, which never quits the case or house where she was born. Some of these cases are remarkable structures formed of grass, or leaves, or moss neatly and regularly put together and lined with silk. The larvæ as they grow of course require a larger home; to meet with this emergency they cut out a piece in the case, so that it opens, and fill in the cavity with the vegetation the case is formed of and then coat it within with silk. These larvæ when they require to crawl, push their head and front of the body slightly out of the case and drag it after them. When stationary they are fixed by a silken cord to the grass or plant upon which they feed. The eggs are laid by the female in the 'house,' and then she dies. As soon as the ova hatch, the young larvæ instantly commence to devour the dead body of their parent and then leave the old house and

form new ones for themselves. The males are winged, delicate insects, with generally a few gray, brown or black scales upon their nearly transparent wings. Parthenogenetic reproduction may take place in these moths.

The family *Notodontidae* is one of no little interest to us. The type of this family is the so-called 'Puss Moth' (*Cerura vinula*), the 'Fork-tail' of the French. This moth is common in England, wherever sallows and willows and poplars abound, and may be found in such damp and swampy places where willows grow any time during May. The wings are whitish with numerous dark wavy and V-shaped markings upon them. The eggs which the female lays turn to larvæ about June. When first hatched the caterpillars are almost black, but as they moult they gradually change in appearance. When full grown they are smooth, with very large heads seemingly drawn back into the first thoracic segment, the third and fourth being raised up into a hump. The last segment is furnished with two long 'tails' (Fig. 30). They are now delicate green with a purplish-brown back, bordered by a band of white. The two tails are very pale green and ornamented with black tubercles. When irritated the caterpillars erect the two caudal prolongations, which are hollow, and dart through them two wavy red tentacles. These two prolongations are undoubtedly modifications of the two posterior legs, the two tentacles passing through them being formed for protection. They thrust them out so as to frighten away

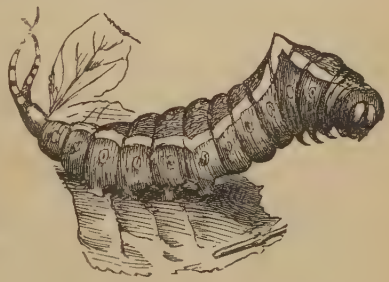


Fig. 30. Larva of *Cerura vinula*.

the Ichneumon flies that attack them. When full-fed these caterpillars spin a cocoon formed of chips of wood amongst the rough bark of the willow and other trees and change to a large brown chrysalis within.

There are many more of this family found in England, such as the curious 'Lobster Moth (*Staurepus fagi*), the Pebbles (*Notodonta*), the Prominents (*Pheosia*), and here belong the 'Processional caterpillars' (*Cnethecampa*) of the Continent.

The family *Saturniidae* is an important one, it contains some of the largest moths in the world and all those, except the 'Mulberry Silk-worm,' that produce silk of any commercial value. They are all large sized and often very densely clothed with hair, the wings have nearly always a transparent spot in the middle or with a dark eye or lunule, surrounded with variously coloured borders. The larvæ which are spiny are often gregarious and live upon various trees, some secrete a curious white waxy powder at certain stages of their growth. One of the largest in this family is the renowned Great Atlas Moth (*Attacus atlas*) of Asia, some species measuring nearly twelve inches in expanse of wing. The large green caterpillars spin dense silken cocoons, hanging from the boughs of the trees by a long stalk. The silk is not of any commercial value, however. The best silk is formed by the larvæ of the Ailanthus Silk Moth (*A. ailanthus*), *Antheraea mylitta*, a large Indian species, and *Yama-Mai* a native of China. In England we have only one representative, namely, the Emperor Moth (*Saturnia pavonia minor*), the green, pink-spotted larva being common on many of our heaths. The male has rich brown front wings and brownish orange hind wings, the female is gray; the borders are white and brown and the wings are traversed with several white lines, and in the middle of each is the black eye. The female is much larger than the male. The Common

Mulberry Silkworm (*Bombyx mori*) belongs to the family *Bombycidae*, a family containing small-sized species and with naked larvæ. This Silkworm was originally a native of China, but it has now been reared in Europe for some 1300 years and until recently it was the chief silkworm. Diseases, however, have become so rife amongst this species that they have now given way to the larger and more paying members of the preceding family. The moth is yellowish-white with two transverse brownish lines and is about 1½ inches in expanse of wings. It is extremely sluggish, and in most cases, anyhow in domesticated forms, incapable of flight. The silkworms are smooth-skinned and of a dirty white appearance, but, according to our chief authorities, the original stock were brown. The moths known as the Eggars and Lackeys belong to a family known as the *Lasiocampidae*. They are usually of a reddish-brown colour in the male and yellower in the female, the latter always being much larger than the male. The Lackey Moth (*Clisiocampa neustria*) is sometimes very destructive to fruit trees in Europe. The caterpillars live when young under tents of silk, amongst the leaves. It is no uncommon sight to see these large masses of silk on our apple trees in England. If they are examined we shall find a number of brilliantly striped larvæ amongst, or on, the silken threads. These larvæ are striped with orange, red and blue, and are covered with hair, the bright markings are divided by stripes of black or black spotted with blue. When full-fed they reach an inch and a half in length. The eggs are laid in the summer or autumn of the preceding year to that in which these creatures appear and attack our fruit trees; the ova may be found in winter attached to the boughs in a compact ring. In May they hatch into small black hairy caterpillars which spin the silken

tent and then grow into the form first described. They do not pass to the ground to pupate, but spin a light silken cocoon anywhere in reach of the food plant. From the dark brown chrysalis within the cocoon, the moth emerges in summer.

The perfect insect itself is very variable in appearance, but they may be roughly described as of a reddish-brown to dark brown tint with two transverse bars, sometimes darker than the ground colour, sometimes lighter. The attacks of the 'Lackey' caterpillars is never so serious in England as in parts of the Continent, especially France, where it was compulsory for all to cut off at once any web of the species found in the orchards and to have them destroyed.

Noctuæ.

The *Noctuae* contain a very great number of families and species, and unfortunately contain many injurious ones. The perfect insects are generally of moderate size, with a stout hairy body, sometimes extending beyond the hind wings; most of the Noctuæ are dull coloured insects. The front wings are generally narrowed, and under these narrow fore wings the hind wings are folded in repose. The posterior pair are often coloured with some conspicuous tint; the beautiful Red Underwings serve as good examples of this, the under wings being a splendid red colour, which are covered in repose by the anterior gray ones and thus render the insect inconspicuous; we see here and in certain South European 'grasshoppers' mentioned later, beautiful cases of protective coloration similar to this. These moths have a long trunk and projecting palpi and the antennæ are generally simple and thread-like. The adults, unlike many of the Bombycidæ, are very fond of

nourishment, especially sugars. Many can be captured by painting the trees with some sweet mixture and watching it of a night.

We shall, on looking through the various species of Noctuæ, see a great resemblance between many of the species; yet on looking at their larvæ we shall see great differences in appearance, habits and structure. The adults all having very similar habits have naturally not varied so much as their larvæ, which often live under very diverse circumstances. The larvæ have, as a rule, sixteen legs and may be slightly hairy. The pupæ are generally naked, but sometimes cases of earth, etc., are formed. The majority, as the name implies, are night flying moths; but in this case, as in many others, there are exceptions to the rule, for we find several Noctuæ, not only diurnal but especially delighting in the bright sunshine. It is only possible to mention a few species of this great group, and those that are injurious to our crops are chiefly chosen.

The so-called 'Surface Caterpillars' are the larvæ of certain Noctuæ, that belong to a large and important genus *Agrotis*. This genus is one of the most typical of the Noctuæ and includes several moderate sized brown species with pale gray or silvery hind wings.

The term 'Surface-caterpillars' is applied by agriculturalists to all kinds of larvæ that live and feed near the surface of the ground. Two of the chief are those of two members of the genus Agrotis, namely the Dart Moth (*A. segetum*) and the Heart and Dart Moth (*A. exclamationis*). The Dart or Turnip Moth (*A. segetum*) has the anterior wings of a pale grey colour, with dark markings, the hind wings are pale pearly white, the female is of a dark brown and the pearly white hind wings are clouded at the hinder edge and have dark rays running up them. The abdomen is brown.

The female Turnip Moth lays her eggs in June and again in the autumn, sometimes on the ground and at others on vegetation. In from two to three weeks the ova hatch, into small brownish-green larvæ. When full grown they may reach 1½ inches in length, and are smooth skinned, with a few scattered pale hairs; they are of somewhat variable colour, some being of a dull brown, others having a purplish tinge, with two dark brown lines running along the dorsum and one on each side. The first segment is brown with three pale lines, the other segments have four black spots upon them above and others low down at the sides.

When first hatched these 'surface caterpillars' feed above ground, gnawing off the plants just above the ground and in this way destroy whole crops of nearly every variety. As they grow they spend more and more of their time beneath the soil, coming up at night to feed, and dragging leaves, etc., down into the earth to feed on during the day. In the case of root crops, they first feed upon the leaves and then when the root is formed, they live within it tunnelling it out in all directions.

The caterpillars live through the winter, sometimes feeding, sometimes in earthen cells, according to the weather. The cold does not apparently damage them. Some exposed during the winter 1892—93 on a tray without any covering were not destroyed, although the thermometer registered more than 20° F. of frost for seven consecutive nights. In the following May they turn to smooth reddish-brown pupæ in earthen cells a few inches below ground. The pupal stage lasts about one month.

In a very similar way the larvæ of the Heart and Dart Moth (*A. exclamationis*) work. The larvæ of this species are of a dull purplish colour, with a pale yellowish stripe along the back, and having an indistinct dark line along

each edge and a double one along the centre of the back. Beneath, these larvæ are pale brownish-green; the first segment is horny and has dark spots upon it, all the other segments have four little tubercles upon them at the top and several on the sides, from each tubercle a hair arises.

The Heart and Dart Moth itself appears in May and June and is of a clay colour, with two spots and other dark brown markings on the wings, which are much darker at their edges; the hind wings are pale white in the male with the nerves brown near the base, in the female the hind wings are brown. The life history is very similar to the Turnip Moth. Both also attack grass and winter corn.

Handpicking is the only practical way of destroying them. This plan is adopted in many districts. The author has seen it successfully done in many market gardens, especially in the case of Cabbages. Handpicking can be done by boys, loosening the earth around the stems and thus turning up the grubs, then collecting them into a pail of quick lime. On a large scale repeated harrowings, so as to disturb them and bring them to the surface, are most effectual. The grubs are thus exposed to the attack of birds, which, especially the Starlings and Rooks, devour large numbers of them. Pigs are also said to hunt greedily for surface grubs and much good may be done by turning them upon newly broken land.

There is another moth closely related to the above, but far more conspicuous, namely the 'Great Yellow Underwing' (*Tryphaena pronuba*). The front wings of this moth are of a rich brown with various dark markings, and the posterior wings dull orange, with a broad black band at the posterior border.

The larvæ or 'surface caterpillars' are larger than the ones just described, and fatter, the general colour is a

dull brownish-green, with pinkish variations, a pale line down the back and one on each side, and with various black spots and markings. Their life history is very similar to those just described, and they damage crops the same way.

The family *Plusidae* contains some interesting species, notably our Common Silvery-Y Moth (*P. gamma*) (Fig. 31). This moth is of a purplish brown on the thorax, and on the large tufts of hair on the abdomen; the front wings are brown and silvery gray, of a satiny lustre and have a curious whitish yellow marking resembling the Greek letter 'gamma' on each wing. The hind wings are silvery with dark veins and a dark clouded border. Their larvæ are green, with narrow white streaks along the back and a yellow streak on each side, and are covered with short hairs. When fully grown they spin a cocoon beneath the leaves of their food plant and turn to the pupal stage. The moths appear all the year round from April to October, but are most abundant in the autumn. The Silvery-Y is found from Greenland to Abyssinia and extends to the frontiers of China and Siberia as well as being abundant in N. America. In our own country they seldom do much damage, but abroad peas, beans and especially sugar beets are often very much damaged by the larvæ of this species.

Fig. 31. Silvery-Y. *Plusia gamma.*

Another type of noctuous moths may be seen in the family *Leucanidae* or the Wainscot Moths. They are small, smooth bodied insects with pale coloured wings, without any ornamentation and with large projecting palpi. The

larvæ of this family are also pale in colour and have no ornamentations. Most of the caterpillars feed on grasses and reeds, the genus Nonagria living in its larval state inside the stems of rushes and reeds and there turning to the pupa.

Unlike the Wainscots, the family *Xylinidae* or 'Sharks' have some very pretty and elegant caterpillars. They are long and cylindrical and slightly attenuated at each end. In *Calocampa exoleta* the colour is bright green and with a pale yellow line connecting the spiracles, intersected with a scarlet streak; there are also white spots edged with black upon them, and altogether they form very beautiful objects. The chaste larvæ of the Mullein moth (*Cucullia verbasci*), which are creamy-white, with a broad yellow band running across each segment from spiracle to spiracle and with black spots, belong also to this group. They are found feeding upon the Mulleins and other scrophulariaceous plants. The moths are all brown or brownish-red insects, often resembling pieces of wood. So great is this resemblance, that when settled upon trees and oak fences they are almost imperceptible.

There are many more important forms in this group, such as the Cabbage Moths (*Mamestra brassicae*), the Herald Moths or *Gonopteridae*, the Red Underwings or *Catocalidae* the large dull coloured American *Erebidae*, exemplified by the Brazilian *Erebus strix*, a dull and sombre coloured insect, often measuring seven inches across the wings.

Geometræ.

The *Geometrae* or 'Loopers' are characterised by an important feature in the progress of their larvæ. The caterpillars have not the prolegs all developed as in the noctuæ and the absence of these prolegs has necessitated

the curious motion of the larval insects. They always move in the following way, the front legs take hold of the twig firmly and then the back part is brought up to the front legs, thus forming the insect into a loop; the front legs then relax their hold and the caterpillar stretches itself out and grasps the twig further along and the hind legs are again brought up to the front and so they progress in this series of 'loops.' They have also a very curious habit of raising their head and body into the air, and remaining stiffened out in that position for some time. Very many of them exactly resemble the colour of the plants upon which they feed, and it is very difficult to discern them when they are stationary. When disturbed they usually fix a thread to the twig or leaf and lower themselves down rapidly by it. Only ten legs are present in these larvæ.

The moths have generally a slender body, with often pectinated antennæ in the male. The largest species do not exceed four inches in expanse; from an inch to an inch and a half is their usual size. Many are beautiful and chaste insects and some are brilliantly coloured, even in our own country. A few of the females are wingless. but the majority have their organs of flight well developed, There are a very large number of families and genera, a few types only being mentioned here, and especially those of an injurious nature. The largest British Geometer is the Swallow-tail Moth (*Urapteryx sambucata*), belonging to the family *Urapterydae*. This moth measures two inches in expanse of wings. It is of a pale creamy yellow, with two dark stripes and a pale streak between on the fore wings, and a single stripe on the hind wings. A short projecting angle is present on the posterior wings, and at the base of each are one or two dark spots. The bright green moths or 'Emeralds', as they are popularly called,

belong to this group of Heterocera, and form the family known as the *Geometridae*. It is an extensive family, with entire or angulated wings and occasionally marked with transverse lines or masses of colour, but never speckled.

The caterpillars of the *Zerenidae*, the family that includes the Magpie or Currant Moth (*Abraxas grossulariata*) often do much damage. The larvæ all feed upon various fruit trees, both leafage and fruit, and at times are very injurious. The 'Magpies' are nearly all white or creamy, with spots and marks of a black or tawny colour. The genus Abraxas to which our common species belongs is a very large one, and especially plentiful in Asia.

The Currant Moth.

(*Abraxas glossulariata*).

The Magpie or Currant Moth is very widely distributed in this country. It has been recorded as doing much damage from the Orkneys to the South of England, often entirely stripping the buds, leafage, and occasionally the fruit of currants (especially black varieties), gooseberries, apricots, peaches, and plums. The author has also seen them devouring the leaves of the hazel, filbert, and cob-nuts to a very serious extent, whilst in the hedge-rows they may often be found upon sloe and maple. The Magpie Moth itself is extremely variable in colour, I have met with them nearly black in the Channel Islands (Sark) and at other times nearly white, the typical forms are, however, creamy white spotted with black on the wings, with a yellow band across the fore wings and a yellow spot at their base. The thorax is yellow with a large black spot in the centre; the abdomen is also yellow, spotted with black. Sometimes, as mentioned above, the black or white predominate, at others the yellow increases,

some have the spots running into stripes and a variety of other forms. The eggs laid by the female during the summer are placed singly upon the leaves of the Currant or their other food plants and the caterpillars, or 'loopers' as they are generally called by the gardeners, hatch during August and September and commence devouring the leaves, and in several cases brought under the author's notice the fruit also has been eaten. These 'loopers' are coloured very much the same as the perfect insects, the head is black with a creamy-coloured body, with a reddish-yellow stripe along each side and large irregular black spots along the back; the whole of the second segment and the ventral surface of the 3rd and 4th and the four nearest the tail are also reddish orange. There are, as in all 'looper' caterpillars, two pairs of prolegs only, placed at the posterior end of the body. These 'geometer' larvæ which are hatched in the late summer, continue feeding until the leaves become shrivelled and dried, and then they bury themselves under the bushes and amongst the dead leaves on the trees, according to Miss Ormerod, and pass the winter in a torpid state. The author has found them during the winter hibernating in crevices of walls and other places. No matter where they pass the winter they appear again in the spring and do far more damage than in the summer and autumn, devouring the buds and leaves incessantly. When full-fed they spin a light cocoon upon the leaves, twigs, or on any other handy object, and turn into a black chrysalis, banded with orange, from which the moth appears in the summer.

The chief object should be to destroy them in their winter quarters as far as we can. There is no doubt that many pass the winter amongst the leaves of the bushes and beneath the ground, although this is not always the case. Collecting and burning the leaves, scraping away and

burning a few inches of the soil beneath, would tend to lessen to a large extent their presence in the spring. A very good plan is to work gas-lime into the soil with a pronghoe during the winter, as this not only will destroy these larvæ but the pupæ of another insect described in Chapter V, namely, the Gooseberry Saw-fly. If gardens are surrounded with old walls, where these 'loopers' can hibernate, the walls should be washed with whitewash, size and sulphur, when the magpie larvæ have been observed abundantly in the previous autumn.

When these depredators are present upon the bushes, dry dressings of flower of sulphur or soot will be found to disperse them. Syringing the trees with any noxious substance can also be done to advantage, whilst a ring of sand or ash mixed with tar and placed around the stems in spring, thus stopping the ascent of the caterpillars, has been found most serviceable. The *Geometrinae* supply us with even a worse pest than the one described, namely the Winter Moth.

The Winter Moth.

(*Cheimatobia brumata*).

Few moths are so hated by fruit growers as the Winter or Evesham Moth. The Winter Moth itself is of a dingy appearance; the male has four well developed wings of a greyish brown colour, marked with bands of a darker hue in the fore wings and of a pale grey in the hind. This and other species of Geometers related to it have no wings fully developed in the females. The female Winter Moth, has only four small patches representing the large membranous expansions of the male. In the March Moth (*Anisopteryx aescularia*), in the Mottled

Umber (*Hybernia defoliaria*), and in others, the wings have *entirely* gone in the female, and the imagines resemble more a spider than a moth. Although small rudiments of wings are present in the female of the Winter Moth, they are quite useless as organs of flight. They are known as Winter Moths on account of their date of appearance, often being taken in the middle of winter, and Evesham Moths on account of their great abundance at Evesham amongst the fruit plantations.

The female '*brumata*', crawls up the stems of the fruit trees and deposits her eggs upon the twigs and especially around the edges of pruned surfaces. They commence laying their ova about the middle of October and go on really during the whole winter. I have met with them in all the winter months to March, when there appears to be a second brood. The eggs laid by the female hatch in the spring into small grey loopers, which become yellowish-green, later pale stripes appear along the body and after the last moult the larvæ are a brighter yellowish-green with a light brown shining head. They reach one inch in length when full grown. These 'loopers' are, however, very variable, some being almost black in appearance, others a dusky green. These caterpillars feed upon the buds, leaves and flowers of the fruit trees, especially the apple and plum, often until the entire tree is stripped of its summer garb, and makes it appear as if scorched by fire. When full-fed these larvæ lower themselves down by a silken thread to the ground and pupate beneath the soil, some few also undergo their changes under the roughened bark of the trees. The chrysalis is enclosed in a case of earth, this stage taking place about May or June. Most of these pupæ will turn to perfect insects in the autumn, but some remain until the following March and appear then. The eggs from this second brood give rise to larvæ some-

what later than those laid in the winter. The larvæ of this second brood often destroy the young fruit as well as the leafage. Several complaints of the spoliation of fruit have reached me this year, 1895.

One of the most effectual methods of checking the spread of the insect is by 'banding' the trees with some smear or grease that will catch the wingless females as they crawl up the trees to deposit their eggs. This 'sticky banding' the trees, as it is called, is done in the following way:—first tie some grease proof paper, which can be bought at a grocer's, some 5 or 6 inches wide around the trunk of the tree, about two or three feet from the ground, by a piece of bast above and below; then cover the paper with some 'Smear', such as ordinary 'cart-grease', bird-lime, or vasaline.

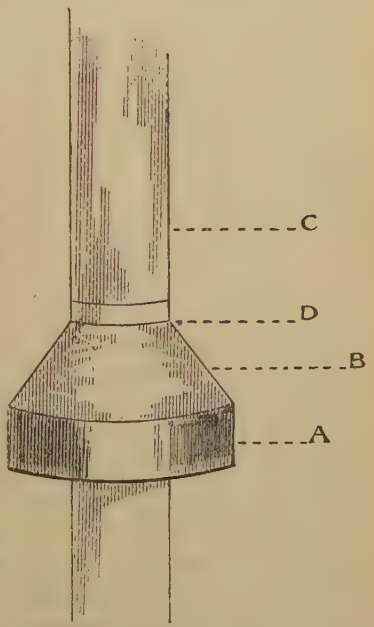


Fig. 32. *Winter Moth Tap.* A. Tin hoop, B. Muslin, D. String, C. Tree.

The females will get stuck in this band and thus be prevented from gaining access to the trees above. This will stop the egg-laying.

Traps of various kind are also used (Fig. 32). The most successful being the one given in this figure. It consist of a band of tin, (A) about 3 inches wide, to which is attached a piece of

muslin (B) and this is tied round the tree (C) with a piece of cord (D). The whole then forms a kind of tent sticking out around the tree, under which the females lay their eggs.

A second important point is to lessen the number of eggs on the tree if they have been laid. It is well known that the females lay most of their eggs towards the ends of the shoots, thus late pruning and burning the debris will destroy large numbers of the eggs laid.

Even if we apply the measures recommended above, we are always liable to the 'loopers' still being present on the trees, as a certain number of females are always carried in 'copula' by the males on to the trees, and it is therefore necessary to have some method of destroying the larvæ themselves when present. This can be done by spraying the trees with a substance called 'London Purple'. The methods of using this insecticide and also another, Paris Green, are given in the Chapter on insecticides.

Amongst other Geometrinæ must be mentioned the 'Carpet moths' or *Larentidae*, one of the largest families, including numerous small or moderate sized species. On the heaths and in pine woods we find the Geometers chiefly represented by an extensive family called the *Fidonidae*, the males having strong pectinated antennæ and with rounded wings, of a pale colour, speckled with minute dots and dark bands, some few being nearly white. Found with these are often members of the *Macaridae* to which family belongs our curious Peacock Moth (*M. notata*) a grey species with dark markings, and near the end of costa a fawn-coloured patch.

There are numerous other large genera such as the 'Pugs' (*Eupetheciadae*) related to the 'Carpets' and other important genera amongst the 'Wave Moths' (*Acidalidae*),

whilst the curious 'Thorn Moths' (*Ennomidae*), in which family is also included the Brimstone Moth (*Rumia crataegata*) also deserve mention here.

Pyrales.

This sub-section of moths in characterised by the long and narrow wings, not folded round the body in repose, very short palpi and a long and pointed abdomen reaching far beyond the wings. They are remarkable for their diversity of habit as well as of form. The Pyrales are very numerous and are generally gregarious. Their larvæ as a rule have a shiny appearance and are generally slightly hairy. They are mostly fond of darkness and remain hidden up, but some of the moths fly even in the brightest sunshine. Some of their larvæ (*Hydrocampidae*) live actually in the water and undergo their metamorphosis there. Many spin cocoons, but some attach themselves in the same way as a butterfly caterpillar before pupating. One of our best types is the somewhat destructive 'Meal Moth' (*Asopia farinalis*). This insect is common in houses and stables, it is a small species with reddish-brown wings, patched in the centre with fawn colour. The larvæ have a curious varnished appearance and their legs only slightly developed. They live upon corn, straw, and even animal matter, and pass to the pupal stage in a silken cocoon. The moths themselves take no nourishment and have therefore a rudimentary proboscis. Closely related is the Tabby Moth (*Aglossa pinguinalis*) also found in houses and stables; the dark brown larvæ live upon greasy horse cloths and even grease itself. The larvæ have their spiracles covered by folds of the outer integument, so that the grease does not block them up. The most curious Lepidopterous larvæ are those of the *Hy-*

drocampidae; they are all aquatic and have two distinct modes of respiration, in some the larvæ are surrounded by a bubble of air and therefore breathe by means of spiracles, in others we find branchiæ or gills; these gills are filaments, strongly resembling those of the larval Caddis-fly. In one, *Paraponyx*, both large branchiæ and spiracles are present. Yet all the varied forms give rise to moths that breathe in a similar way. Nettles will always yield another genus, *Botys*, containing the Small Magpie Moth (*B. urticalis*), a white species with two rows of black spots on the wings. Most of the others of this extensive genus are grey or yellow and many have a beautiful pearly lustre, hence the name of 'Pearl Moths', often applied to them. One of this section, the 'Garden Pebble' (*Pionea forficalis*) has often been recorded as doing damage to garden crops such as cabbage and kale, in its larval state, but it seldom appears in sufficient numbers to call for any special attention.

The Crambi.

Everyone has noticed when walking across any grassy patch, small pale coloured moths flying away at their approach. These are members of the sub-section called by Entomologists Crambi, and popularly 'Grass Moths.' The 'Grass Moths' have long wings, the front ones narrow and the hind ones broad and with long palpi. There are four important families of the Crambi, one being interesting to the bee-keeper, the *Galeriidae*, as the larvæ are parasitic in the nests of bees, especially when the 'stocks' are weak. The second family, the *Phycidae* or 'Knot-Horns', derive their name from the males of several species having a curious tuft at the base of the antennæ. One species (*Zophodia convolutella*), a grey species with two zigzag white lines surrounded with blackish on the fore wings,

is injurious to the gooseberry on the Continent, the larvæ feeding on the unripe fruit. The true Grass Moths or *Crambidae* are characterised by the curious tubular form the wings are folded in, when at rest.

The Tortrices.

The *Tortrices* are a very large group of small moths, characterised by the narrow body, not extending beyond the hind wings; the fore wings, short, broad and truncated at the extremity, and hind wings broad. As the name implies, the larvæ live in rolled-up leaves to a large extent, but there are many others that live in seeds and seed capsules, and in the flower heads of plants. Unfortunately there are some very destructive creatures in this group, as all those who are acquainted with apple culture know, as well as other fruit cultivators. Most of the larvæ are pale in colour, green being a predominent tint, they are extremely delicate and often covered with fine hairs. Those that are leaf-rollers, as the beautiful Green-oak-Tortrix (*T. viridiana*), so destructive at certain times to our oak trees, turn to the pupal stage amongst the leaves, others spin several leaves together and pupate in them. One of our commonest species and one that is injurious as well, namely, the Codlin Moth (*Carpocapsa pomonella*), may be taken as our type.

The Codlin Moth.

(*C. pomonella*).

The premature fall or 'summer fall' of apples is often due to the work of the larvæ of this moth. If a 'wind fall' is picked up, in most cases a small black round hole

will be found on the surface of the apple, this is the exit of the maggot that has caused the premature fall of the fruit. The Codlin Moth is about ¾ths of an inch in expanse of wings, which are of a light grey, with delicate streaks of a copper colour and with a dark coppery patch towards the hind angle of the front wings; the posterior wings are dark brown. This moth appears in the early summer and lays her eggs upon the young apples, when they are forming; one egg is usually laid in the eye of each apple. From this ovum the maggot eventually hatches, and at once commences to gnaw a tunnel into the apple. When full grown the maggot is about half an inch long and slightly hairy, in colour it is nearly white, with a brown head and a few dots on the segments. At first it continues tunnelling through the apple until it reaches the other side, it then forms a hole in the rind and returns by the same route and enters the core, and there it feeds for a little while on the pips only, thus causing the fruit to fall. The maggot then leaves the apple, crawls up the trunk of the tree and finding some sheltered space beneath roughened bark, spins itself a small silken cocoon. In this cocoon it remains throughout the winter, and in spring pupates and hatches about June into the perfect moth.

The most important thing in apple orchards, is to keep the trunk of the trees clean. By scraping off all rough bark we destroy the shelter which the larvæ look for to pupate under, and thus in a large way destroy them. A very good and practical way is to tie a piece of old sacking or any rough cloth around the base of the tree, the maggots finding this, spin their cocoons in it, and the cloth can then in the winter be taken away and burnt with the pupæ in its folds. Spraying the trees when the fruit is young with Paris Green or London Purple is an excellent plan, as

it lodges in the eye of the apple and destroys the egg or young maggot. The trees should be sprayed for the first time just after the bloom has fallen. The second dressing should follow in about two weeks, and a third about two weeks later.

Another destructive tortrix in the Pea Moth (*Grapholitha pisana*), causing the so-called 'Maggoty Peas', which are often found in old pods and even in the peas when stored. The moth, which is about half an inch in expanse of wings, is mouse-coloured and of a satiny hue, the costal border has a row of white streaks along it and a silvery ring with five small dark lines placed inside the ring. The moth appears in June and lays her eggs in the young pod. The ova hatch into hairy, fleshy, white maggots with a dark head and dots on each segment of the body. They reach about $\frac{1}{4}$th of an inch in length and then pass to the ground to pupate, in a silken cocoon, but not until the next spring.

Another example of this group is *Carpocapsa splendana*, the larvæ of which live inside the edible chestnut. They also attack walnuts in a very similar way. Many of these larvæ are very active inside the fruit; a curious case is mentioned by M. Lucas, who records some Euphorbia seeds when heated, jumping up into the air some distance, the result of the caterpillar inside jumping about. Forest trees as well as fruit suffer from the Tortrices, the Pine-Bud Tortrix (*Retinia turionana*) doing much damage in its larval state to the young pine buds, while numerous others attack all kinds of vegetation. Teazle heads seem a favourite resort for many kinds, whilst strawberries have this year suffered largely from Tortrix pests. A very large number, especially of the typical genus *Tortrix*, are found in hazel woods, where their larvæ roll the leaves up into all manner of shapes.

The Tineæ.

A few people only can fail to be acquainted with this group, as it contains the well known Clothes Moths

Fig. 33. Goat Moth and Larva. *Cossus ligniperda.*

(*Tinea tapetzella*), as well as the farmers' great pest, the Diamond-back Moth (*Plutella cruciferarum*). Most of the *Tineae* are small moths with long narrow wings, with long fringes of hair, not wrapped round their body in repose. They are very numerous in Europe, one third of our British Moths belonging to this section.

Recently Dr. Chapman has told us that the huge Goat Moth (*Cossus liguiperda*), Fig. 33, belongs to this group of moths. Very few of our species reach an inch in

expanse, but the Goat Moth, if it is really one of this group, often reaches four and a half inches across the wings. Many of these *tineae* do much mischief in houses to clothes, carpets, and all manufactured goods.

The Clothes Moths (*Tineidae*) are one of our worst indoor pests, the commonest form is *T. tapetzella* which has its fore wings black to the middle and white and brown beyond. The little caterpillars of this moth form a protecting tube, almost cylindrical in shape, made out of the cloth and other stuffs it eats away. Some of these tubes are very curious, being enlarged as the insects grow, it often happens that different coloured materials are used to form the new parts of the old case, which may have been brown, while the new part is red or green or some other colour.

Before they pupate the larvæ close one end of the case and hang it up before turning to the pupal stage. Other species as *T. pellionella* attack furs and do much mischief in fur stores, another, *T. crinella*, attacks skins, feathers, and horse hair. Others, such as the destructive Mediterranean Wolf Moth (*T. cerealium*), live amongst grain in granaries and do a great deal of mischief. Mention has been made of the curious cases formed by the *Psycidae*, in the Tinea we again find a similar habit exemplified by the genus *Coleophora* and *Gelechia*. It is not unusual to find the dry calyces of the common Marjoram fastened together lengthwise, when the plant is going off blossom. If these are examined, a minute larva will be found within. They are formed by the larvæ of *G. subscella*, which feed upon the seeds and when they have eaten the contents of one flower they bite off the calyx, and using it as a case, proceed to another flower and so continue until they are enclosed in a floral bower.

In these structures they undergo their metamorphosis.

G. syringella, the Confluent-barred Moth, Fig. 34, is a pretty species with ochreous yellow upper wings mottled with brown, and having at the tips an eye-like spot with a dark centre. The young larvæ burrow into the leaves of the lilac, etc., but when about half grown it crawls out

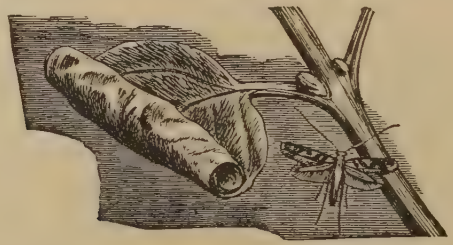


Fig. 34. One of the Tineæ. *Gracillaria syringella.*

and rolls up another leaf, as seen in Fig. 34. This is done by a curious system of silken cords by this minute larva. There are also a very large number of small Tineæ that live in their larval stage between the two layers of the leaf, these 'miners' are numerous and often do considerable damage, especially to ornamental plants. Everyone must have noticed the tunnels formed in the honeysuckle in such great abundance, they are formed by two members of the group *Lithocolletidiae*. The *Nepticulidae* or Pigmy Moths also burrow in the larval state in the same way (Fig. 35). The genus *Depressaria*, the so-called Flat-bodied Moths, is also another of importance to us, they are all dull coloured insects, with much broader wings than most of the Tineæ; most are grey and brown moths with one or two black dots upon the wings, which are very much flattened in repose, hence their name. Two of our commonest are the Flat-bodied Moth (*O. cicutella*) and the Carrot-blossom Moth (*O. daucella*). The larvæ of both these species destroy the leafage and flower of

the Carrots. The larvæ of the former feed on the Carrot-leaves, which they cut so that they can bend them round into little tubes spun together by silken threads, each end of the tubes being left open so that when alarmed the

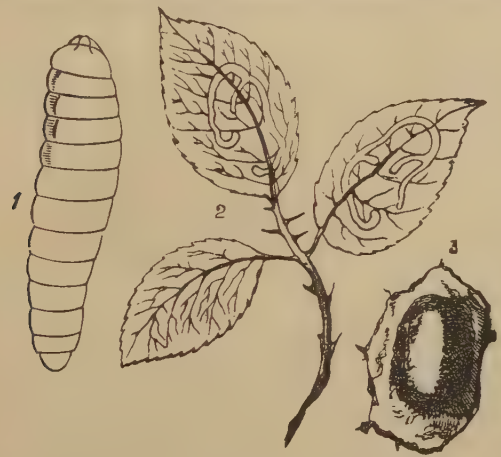


Fig. 35. Leaf Miner. Nepticula aurella.*

occupants can fall down to the ground. The little green larvæ have black warts on each segment, and two brown spots on the first segment behind the head. Before they pupate they become a rosy colour beneath. The metamorphosis may take place amongst the leaves or in cocoons in the ground. The moth itself is about $\frac{3}{4}$ths of an inch in expanse of wings, of a pale reddish yellow colour, the upper wings freckled with brown and black and with a few white dots with dark edges towards the middle.

There are two broods, one springs from the caterpillars found in June, these hatch in August; the other arises

* The upper wings of this moth, the Golden Pigmy are golden brown, deep purple beyond the middle, with a burnished gold band across the latter. The larva, Fig. 35, mines the bramble leaves.

from larvæ found in September; the latter hatch as perfect moths in November and hibernate until the following spring. The other species (*daucella*) lives upon the flower heads. Both have a constant and dangerous enemy in the Sand Wasp (*Odynerus*).

One of our worst turnip pests, after the Turnip Flea Beetle, is a member of this Section of Moths, namely, the Diamond-back Moth, which we will consider before leaving the Tineæ.

The Diamond-back Moth.

(*Plutella cruciferarum*).

The Diamond-back Moth has a very wide distribution, not only does it do damage all over Europe, but also in Africa. In Scandinavia it is very plentiful. In 1892 the author saw many fields destroyed by this insect in Norway. It is the only Lepidopterous insect found in Spitzbergen, where it again even does damage. Luckily for us in England, it only appears in large numbers now and then, but when it does appear it is often terribly destructive. In 1851 the caterpillars of this moth are recorded as having appeared in enormous numbers, in England and Ireland, in some cases entirely destroying the crop. Again in 1884 and 1889 much damage was reported amongst the root crops. The year 1891 was, however, the most disasterous one we have had. These moths appeared in swarms, but they were chiefly confined to the E. coast, and they were seldom recorded as doing much damage more than ten miles inland. The attack extended from Kent into Scotland. Several fields badly attacked came under my notice in Surrey and Cambridgeshire and notes of its presence in great abundance in Huntingdon-

shire reached me as well. The moths, which are small creatures, seldom exceeding ⅔rds of an inch, have long and narrow fore wings of a brownish-grey, but much darkened towards the centre, with a creamy white wavy band along the hinder margin. When at rest and the two front wings meet, these wavy white lines unite and form diamond-shaped patches along the back, hence the name of Diamond-back Moth. The posterior wings are narrow and grey, with a very long fringe of delicate hairs. The females, which appear in June and even May (my earliest note being May 5th), lay their eggs in groups upon the leaves of the turnip and other roots. These eggs soon give rise to the larvæ, which at once set to work and greedily devour the leafage. The caterpillars are spindle shaped in form, grey at first but becoming green, with sixteen feet, their head is usually yellow or brown, black according to some foreign observers (and I have myself met with this colour in Norway). The segment next the head is marked with minute black dots, the following two have each an oval mark of yellow on either side of the middle line; the remaining segments have all black dots upon them. When full grown they reach half an inch in length and spin themselves a silken cocoon which is open at each end and attached to the leaf or on the ground. One end of the cocoon is blocked up by the larval skin and the other remains open, for the exit of the imago. The pupa within the silken case is pale brown or grey with several streaks of black upon it. In warm weather the pupal stage often only lasts a week or ten days, but a succession of cold rainy days seems greatly to check their development. There seem to be a very large number of broods in the year. They appear as late as October. Sudden changes of temperature and excess of wet are found to be most prejudicial to their well being. There

is no doubt that the excessive rains in the latter part of 1891, went a long way in destroying the hords of larvæ along our Eastern coasts. During that year the roots and cabbage, the Thousand-headed-Kale and other plants were stripped, not only of the soft part of their leaves, but even of the ribs and stalks as well.

One of the most important points to remember is that this insect naturally feeds upon the wild Cruciferæ, especially on those two common weeds 'Jack-by-the-Hedge' and 'Wall-Mustard', and therefore their destruction would lessen to a very large extent the natural abode from whence many of the moths arise and appear in large numbers, when some specially favourable climatic conditions are present. When the larvæ are present, it is found an excellent plan to dust the plants *when the dew is on the leafage*, with soot or road dust. This can be applied by means of that useful instrument the 'Strawsoniser' far better than it can be 'broad cast' by hand. There is also a good plan often adopted, of attaching boughs to the 'scufflers' in front and taking them through the fields. The boughs frighten the larvæ off the leaf, (they lower themselves down by silken cords when frightened) and the scufflers or a little plough coming after naturally destroy very many on the ground.

There are two other sub-sections of the Heterocera, namely, the *Pterophori* and the *Alucitae*. These two sub-sections have their wings split up into feathers. The *Pterophori* or 'Plume Moths' have the anterior wings split into two feathers and the posterior into three. The *Alucitae* have each of the wings split into six feathers, our small brown Twenty-plume Moth (*A. hexadactyla*) being an example of the latter.

CHAPTER VII.

THE DIPTERA OR TWO-WINGED FLIES.

General account—Nematocera—Fleas—Gallg nats—Wheat Midge—Hessian-fly—Culicidae or gnats—Tipulidæ or Crane Flies—the Fever Fly—*Brachycera*—Tabanidæ or Gad Flies—*Proboscidea*—Syrphidæ or Hover Flies—Eristalidæ—Oestridæ or Warble Flies—Muscidæ—Anthomyidæ—Cabbage Flies—Onion Fly—Carrot-Fly—Celery fly—Gout Fly—*Eprobos-cidea*.

THE *Diptera* or two-winged Flies are a very natural

Fig. 36. Lasioptera rubi.

order of insects. They are characterised by the presence

of only two wings in a fully developed form. The posterior pair *are* present but are reduced to mere club-shaped processes, known as *halteres*, balancers or poisers. The two anterior wings are flat membranous expansions, with few nervures and never covered with scales, but hairs of various forms may be present on and around them. There are certain diptera, such as the Fleas (*Pulex*) and Sheep Ticks, that are entirely apterous, and in the females of others (*Borboridae, etc.*) we shall also come across wingless forms. These are only exceptions, the general characteristic, the presence of only two wings holds good in all other cases. In certain groups of Flies, there is an enlargement at the base of the wing, called a winglet or alula, very clearly observed in the Blow Fly. The mouth parts of Diptera are very varied, some being formed for suction (as *Bombycidae*), others for piercing (*Tabanidae* or Gad Flies), whilst others have the mouth parts rudimentary (*Oestridae* or Warbles), the adults then taking no nourishment. We never find a sting present in this order of insects, the wound, or so-called sting, of a fly, is inflicted by the mouth; they *bite*, not sting. The labium of the mouth is greatly elongated, and forms a kind of gutter for the reception of the lancet-shaped maxillæ and mandibles. The proboscis made up of the labium, etc., ends in a fleshy swollen tongue, and is closed above by the upper lip or labrum. No maxillary palpi are present. The head of the fly is usually large and spherical and united to the thorax by a short neck. Two large faceted eyes are present, and there may be ocelli as well. In the male the compound eyes often join in the middle line. The thorax is large and compact; the prothorax very much reduced and attached as a collar to the mesothorax, which is very large and is developed at the expense of the other two regions. The abdomen is generally small, but may be elongated as

in the *Tipulidae*, or very large as in the Blow-fly, and flattened from left to right as in the Fleas, whilst in other groups, *Tabanidae* and *Stratiomyidae*, it is flattened dorso-ventrally.

The nervous system of the flies is very varied. In some the ganglia are all separate, in others the thoracic even fuse with some of the abdominal. The Diptera form a very large order of insects. When they have been fully worked in England and abroad I believe they will fully equal, if not exceed the number of Coleoptera in the world. In our own country very little is known of them, more is certainly known on the Continent of Europe, but even there only a small amount of work has been done in this group. In the tropics of Africa and America, in India and Australia our knowledge is very scanty. Why they have received so little attention is difficult to understand, as they present many interesting and peculiar features, life histories and habits, and many are no less beautiful than the butterflies. As to their injurious nature they have certainly attracted much attention, for here we find some of our most deadly pests, not only to vegetation, but to our farm stock, and even man himself. The metamorphosis of the flies is complete. The eggs are laid by the female sometimes in patches, sometimes singly, they are usually small oval or spindle shaped bodies, of a white or black colour. They are laid by the female on the substance upon which they feed, and usually in a week or ten days give rise to small white maggots. The larval or maggot stage of the flies is the one in which so much damage is done. The larvæ are as a rule white cylindrical or barrel shaped maggots, destitute of any true legs. They are composed of thirteen segments as a rule, but in some, as the *Cecidomyidae* (Fig. 37), there are fourteen segments. The head is generally horny and armed with the ordinary

mouth parts, some, however, have rudimentary heads, their mouth parts being reduced to simply a pair of hooked mandibles (*Oestridae*). A small pair of antennæ are usually present on the head and in some the eyes are well formed. The body may be naked or covered with hairs or bands of bristles (Bots). Occasionally fleshy prolegs are developed (*Chironomus*, *etc.*) and also fleshy tubercles around the anal region (*Tipula*). Most of the larvæ are land forms, but some, such as the Gnats (*Culicidae*), the Midges (*Chironomidae*), and the Rat-tailed flies (*Eristalidae*), are aquatic in their habits. In the water loving creatures there are special modifications of the breathing apparatus. The spiracles are reduced to two and placed at the anal extremity, so that when they require to breathe, they approach the surface of the water and erect their tail above it and breathe through the stigmata at its extremity. In the *Culicidae* or gnats we shall find other accessories for this method of respiration, namely, groups of hairs around the stigmatic openings, so as to retain bubbles of air under the water. Not only do we find fresh-water aquatic forms, but marine forms also, the family Chironomus having larvæ found in the sea.* The larvæ of many Diptera are also parasitic, some upon other insects (*Tachinidae Volucella*, *Conops*, *etc.*), some upon animals (*Oestridae* and *Sarcophagidae*). When full grown the maggots may or may not cast their larval skin prior to assuming the pupal stage. The pupæ that are naked

Fig. 37.
Larva of Cecidomyia.

* An 'Account of British Flies'. Theobald. Vol. 1, pp. 171—202.

are very varied in shape, some have no covering at all, others (*Mycetophilidae* or Fungus gnats) have a slight silken mass around them. The pupæ are often armed with bristles and spines and are found in and on the ground, amongst moss and in rotten wood. The pupal stage is a true quiescent stage in the flies, but certain groups (*Culicidae* or gnats) have extremely active pupæ, but they take no food and their legs, etc., are swathed up in a pupal case, the metamorphosis of the gnat being just as complete as the metamorphosis of the butterfly. Those that retain the old larval skin are called '*puparia*'. The maggot instead of throwing off its skin when assuming the pupal state, retains it. This skin hardens around the chrysalis and forms a case for its protection.

There are a very large number of families of Diptera and it is not possible to deal with more than a few types here, the more interesting and injurious ones being again taken as in other chapters. There are two great sections in the Diptera, the first characterised by the larvæ having a chitinous head and by the pupæ escaping from the larval skin by a T-shaped opening, the second by the larvæ having no chitinous head and the pupæ escaping from the larval skin by a circular opening. The former, the *Orthorrhapha*, is divided into two smaller groups, the *Nematocera* and the *Brachycera*, the former having thread-like and many-jointed antennæ, the latter having the antennæ composed of two large basal joints with a terminating bristle.

The Fleas or Pulicidæ.

The Fleas or *Pulicidae* are the first family of Diptera. They were usually considered as a separate order of insects under the name *Aphaniptera*, but are now included

amongst our true flies as Diptera Aphaniptera. These curious and obnoxious creatures have excited the interest of naturalists and the general public for very many years, both on account of their noxious habits and of their great strength. The fleas themselves have never any wings, but in some, scale-like plates are found where the wings of other insects are, these scales doubtless being the remnants of the once present wings, that have gradually disappeared through disuse; with the disappearance of the wings, a gradual enlargement and complication of structure in the legs took place, giving rise to those wonderful leaping movements so well known in this group. The body of the flea is flattened from left to right, and is composed of a number of segments of similar structure.

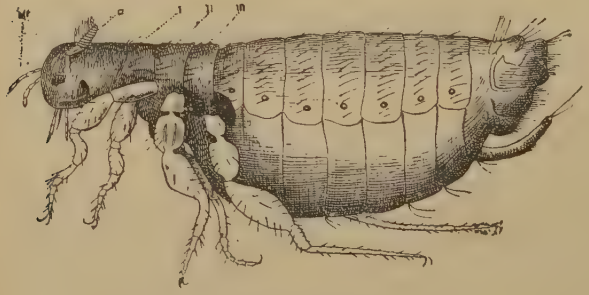


Fig. 38. Human Flea. *Pulex irritans.*

The thorax, composed of three separate segments, is a feature well worth noticing, all other members of the diptera having the three thoracic segments united. The head is large and closely united to the first thoracic segment. A pair of large compound eyes are seen in most species, but in the mole fleas, bat fleas and rat fleas we shall see these eyes are wanting or rudimentary. A pair of antennae are also present, being withdrawn into

a little pit. The mouth is formed of several lancet shaped pieces forming a tube or spear, which it plunges into its victim. The female is armed with a curved ovipositor. The eggs or '*nits*' are laid in dust and dirt and according to some authors, in the case of the human flea, in the scurf of the head. These 'nits' hatch rapidly into small pearly white maggots (Fig. 39), composed of fourteen joints; and having a curious process on the chitinous head, with which it ruptures the egg shell and so escapes. The body may have present a few scattered hairs. The white larvæ which are found in the dust are said to be fed by

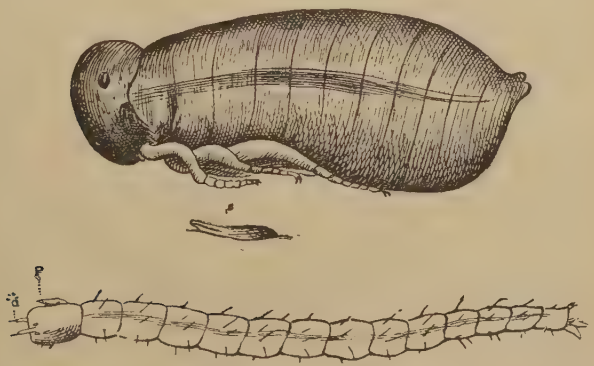


Fig. 39. Pupa and Larva of Flea (*Pulex*). a = antennæ, P. = Post-frontelle.

their mother. She is supposed to gorge herself with blood and then disgorge it near her offsprings. Eventually the maggots turn into immobile nymphs also found in dust and dirt, and in a short time the perfect flea hops out of the pupal case.

Situated on the prothoracic segment are a series of teeth-like processes, called the 'comb,' the number of these teeth serves as a very easy method of separating the various species. There are possibly sixteen kinds

found in England, living upon various animals. The Hen Flea (*Pulex gallinae*), a small almost black flea found abundantly in dirty hens' nests and fowl roosts, being one of the best known after the human species (*irritans*). The species found on the mole and the mouse (*Hystrichopsylla obtusiceps*) has no eyes at all, whilst the members of the third genus, *Typhlopsylla*, which are found upon the bats (*T. octactenus*), the various species of Mus (*T. musculi*) and others have the eyes either rudimentary or wanting. One terribly harmful species is found in S. America and the West Coast of Africa, namely the 'Jigger' or 'Jighoe' (*Pulex* [*Sarcopsylla*] *penetrans*). The female of this flea, which is found in dry and sandy places, works her way under the toe nails and into the flesh of the legs and even backs of men and women, and there, if she has been pregnated, her body swells into a large sac full of eggs, which if left alone soon bursts and gives rise to a number of maggots which set up ulceration and often render amputation of the affected part necessary. The male leads a free life. The larvæ pass out of the host and are said to pupate in the ground. The family of fleas are found in all parts of the world, from the huts of the Eskimo to the huts of the negroes in the tropics.

The next family is the important group of *Cecidomyidae*:—

The Cecidomyidæ or Gall-Gnats.

This family of flies which I wish to bring to the reader's notice is the family of 'gall-gnats,' to which belong the Hessian fly (*C. destructor*) and the 'red maggot' or wheat midge (*Diplosis tritici*). They are all small delicate species, clothed with long hairs, which you see in Fig. 36, and you also notice the hairy long

antennæ, from 24- to 12-jointed; and you notice the most important feature, *viz.*: the small number of veins in the wing. There are a large number of these small 'gall gnats,' and they all attack plants, and produce swellings and rugosities on stem, leaf and stalk (Fig. 40); others attack the blossoms of plants, and thus destroy their reproductive powers. Let us follow the life history of one of these gnats, and let us take one that may have come to your notice, not by means of the gnat itself, but by the disease it produces. Possibly some readers have noticed that suddenly the lower branches of the ash trees have become yellow, as if dying off, and have said that tree is blighted. In Surrey and Kent this is a common sight. It is the work of one of these gall gnats —the ash gall-gnat (*C. fraxina* or *D. botularia*). The female fly deposits her eggs on the ash leaf, and the larvæ or maggots hatch and burrow under the surface of the leaf; here they form a gall down the centre of the leaf, in some instances the gall looking like the swollen mid rib (Fig. 41); the presence of the maggots destroys the nutritive powers of the leaf, and thus it turns yellow; hundreds of these flies attack a tree, especially the lower branches. The maggots are in this family 14-jointed, white cylindrical grubs, with a horny head, and require much moisture to keep them alive. They fall out of the galls produced on the ash leaf before they enter the second stage to the

Fig. 40. Galls produced by *C. veronica* and *C marginem torquens.*

earth, and there they turn to pupæ or nymphs. After a little while the fly appears, or, it may be, it does not appear until the next year.

Fig. 41. Galls of Ash-Gall gnat (*D. botularia*).

You may often have complained of your pears being blighted and dropping off; this is again the result of the maggots of a gall-gnat (*D. nigra*).* The little white maggots live in the pulp of the pear, forming blackened passages from the centre, and eventually destroy the nutritive powers of the fruit so much that they fall off.

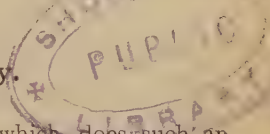
The Wheat Midge.

Then there are the maggots of the wheat midge (*D. tritici*), known as the 'red maggot' or 'red gum' by farmers, which live in the florets of the wheat and destroy the grain. The perfect insects fly about amongst the wheat when it is flowering. The fly is very small, and pale orange coloured. The maggots may go down to the soil to change to pupæ; the latter are reddish coloured. The pupæ hibernate and turn to flies in June. As much as eight per cent. of a crop is often damaged by them.

To destroy this pest, as the parasites are not known much about, we must still recommend (i) the process of burning the stubble, and (ii) also deep ploughing in the following way, *viz.*: by having a skim-coulter, attached

* This is the same as the *D. pyrivora* of Riley.

to the plough in such a way that it would take off an inch or two of surface and put it in the preceding furrow, in this way burying the maggots to such a depth that would render their escape impossible. (iii) The burning of chaff heaps will destroy many, for over the chaff heaps the breeding chiefly takes place.



The Hessian Fly.

The Hessian fly (*C. destructor*), which does such an immense amount of damage in America, has not until recently been noticed in England. In 1886 it is said to have been first found; this, however, is not the case, as I find a record of it several years before; but before 1886 little was known of it in this country; since then numerous accounts and reports have appeared.

The eggs of this fly are small white cylindrical bodies, and are laid by the female on the leaf of the young wheat plant; the small whitish maggots crawl down the leaf when hatched, and bury themselves in the leaf sheath, where they undergo curious changes. By their sucking the juices of the plant they so weaken the stalk that it bends down just above the point of attack, and do in this way great damage to the crop, not only by laying it down, but also by destroying the quality of the grain. The *flax seed* stage is next produced; this *flax seed* stage is the second stage of the maggot's existence. The skin hardens around the larva, and gradually darkens and assumes the appearance of a flax seed, hence the name of this stage. The first larval stage is what is called the *feeding* stage, in contrast to this second stage (flax seed): in the latter the larvæ are called '*puparia*.' These puparia or flax seeds give place to another period of free larval life and then the true pupal stage appears.

When in the flax seed curious phenomena take place. These maggots have in their ventral surface a process known as the 'breast bone' or 'anchor process,' consisting of a stalk and fork at the end. The function of this 'breast bone' for a long time has puzzled naturalists, and not until quite recently has its true function been discovered. When the larva crawls down the leaf to the stalk it must go down head first, and during its *feeding stage* we find it in this position, with head downwards and inwards; the second stage or 'flax seed' being reached, Mr. Enock has made the notable discovery that the maggot by means of this anchor process turns itself gradually round until its head becomes upwards and turned outwards, and thus in this position it turns to the pupal or last stage, and is ready to force its way out of the corn stalk. The anchor process becomes a hard horny beak on the pupa, and with this it breaks its way out.

In America where this insect is two brooded there are two distinct modes of attack, and the second mode is very different to the one just described. The second brood attack the young autumn sown wheat, and render the leaves dark green, destroy the central leaflet, and turn the wheat plant to a rank growing weed. The flax seeds in this attack are found just above the ground; the feeding stage before, having been passed even under the surface. The wheat, barley, and other plants are entirely destroyed in this way in America, hundreds of acres being devastated. In England we are luckily not subject to this attack, and I agree with Professor Riley in considering that we shall never be liable to it, for this reason, our autumn sown wheat is much later than in America, and thus the flies of the second brood are out and dead before the plants are up.

The fly itself is a small brownish hairy insect, with very

hairy wings, and it has pinkish markings on the abdomen in the female and almost black in the male.

There have been countless methods of destroying this pest invented; but *Nature* has provided the best and cheapest remedy, *viz.:* the destruction caused by parasites. Now this Hessian fly is subject to a number of these parasites, in the form of small *hymenoptera*, and these little insects destroy the Hessian fly larvæ and breed much quicker, as shewn by the following results given by Mr. Enock.

In 1887, from 1309 flax seeds he bred 358 parasites, 280 flies = 78 more parasites than flies.

In 1888, from 1458 flax seeds he bred 232 parasites, 211 flies = 21 more parasites than flies.

In 1888, from 1694 flax seeds he bred 319 parasites, 261 flies = 58 more parasites than flies.

So we see the parasites increase more than the flies, and thus by destroying the flax seeds we destroy many of these invaluable parasites, which will themselves do the good we are trying to do. For this reason, many years ago, the great American entomologist, Dr. Packard, strongly went against the habit of burning stubble, often recommended. The above table will, however, shew the fallacy of so doing.

The *Culicidae* or gnats are of considerable interest and so also are the Midges or *Chironomidae*, but as the latter are unimportant economic insects and at present little understood, only a short account of the former family is given. All the gnats are small and delicate insects, too well known in all parts of the world.

On examining a gnat you will first notice the beautiful feathery feelers (antennæ), and then between them the mouth parts which form the piercing organ by which they suck your blood. It is the female only that takes this

liberty; the warmer the weather the more she requires refreshment. Curiously enough, before they commence their blood-loving habits they emit no sound; in the spring no sound whatever is produced by a gnat, but as soon as warm weather comes and they become bloodthirsty the humming noise commences; the warmer the weather the more intense it becomes.

The history of the gnat is curious. They are aquatic insects, both the larvæ and pupæ being found in the water. On the eighth segment of the abdomen is a curious organ used for respiration; this long respiratory tube ends in a radiated mass, and on coming to the surface this tube takes in air to the air tubes (*tracheae*); the last segment of the body is terminated by setæ or hairs and by five conical plates. The larvæ soon pass to the pupal state, which is not as is usual; for these pupæ are extremely active creatures, and they are armed with two tubular horns on the thorax for breathing purposes. They swim by means of the tail and two swimming terminal organs. The two air tubes are usually above the water, so the pupa breathes; when about to hatch, the curved nymph flattens itself out along the surface, and the thorax splits, and by degrees the gnat comes out and rests upon the 'boat' formed by its shell; many are destroyed by the capsizing of these fragile crafts, but if once the gnat gets its legs out into the water it is all right, it rests on the surface and its wings soon dry and off it flies.

The tube of the larva is open when at the surface, but on descending it closes, and a bubble of air remains on its tip.

The Daddy-Long-Legs.

(*Tipulidae*).

The only other important family in the Nematocera with

which we need deal is the family of the Daddy-long-legs or Crane Flies, whose larvæ live upon vegetation, some upon rotting wood, but the majority on the roots of plants.

Everyone knows the insect called the 'crane fly' or daddy-long-legs, which you can always distinguish from any other fly by the long spidery-looking legs, which so readily break off. Now let us examine the history of one of these flies, and for this we will take the common crane fly (*T. oleracea*), which is so abundant in all fields, especially in damp ones. The insect is brownish grey with a silvery hue, and the veins of the wing are testaceous. The female, which is armed with a tube (ovipositor) for depositing her black eggs, places the latter at the bases of grasses and as near the surface as possible, and for a locality she generally chooses a damp situation. These eggs soon hatch into maggots, which burrow into the soil and destroy the roots of grass and corn. These are known under the popular name of 'leather jackets;' the 'leather jacket' derives its name from the extremely hard and tough coat it has: these 'leather jackets' are brownish in colour, and measure one-and-a-half inches when full grown. Whole acres of grass and corn are destroyed by this pest, which also does a large amount of injury to cabbage, lettuce and other vegetables. They turn to pupæ from July onwards, and it is a common sight to see the empty pupa cases sticking out of the grass or sides of the gravel paths in gardens. The pupæ, are armed with hairs and bristles, by which they escape from the ground, working their way up with them. The female lays her eggs in the autumn. Now, as this is one of the most important and troublesome insect pests, a few methods of preventing an attack or of lessening it when it has already begun are given.

1. First of all, thorough draining of damp lands has a strong tendency to lessen the attacks.
2. The use of the 'brush harrow,' which disturbs and prevents the deposition of the eggs.
3. Rolling infested lands at night with a Cambridge roller destroys thousands of the grubs, which come up during the evening and night; but this incurs extra labour, and cannot always be done.
4. The deep ploughing in of old pasture buries and destroys the grubs and eggs.
5. The most important is nature's remedy, *viz.*: the destruction of the grubs by starlings and rooks; these two birds destroy thousands and thousands of these pests, and should be well protected.
6. Dressings of gas or quick lime are also very useful in destroying the grubs; but salt, sometimes recommended, is quite useless, as the leather jackets can live in brine owing to their thick skin.

There are a great number of this family of flies in England, they mostly are found in the same damp situations as the crane fly; the next most abundant is a yellowish species known as *T. maculosa*, which is often very destructive to crops.

The *Bibionidae* are another family of some importance economically; they are mostly dark coloured insects, some few being of a reddish shade. In the male the eyes are always contiguous, in the female they are small. The legs and the body are stout and short. Most of the larvæ live in dung and damp earth but some live upon the roots of plants. One of the most abundant and the only one so far recorded as doing any damage is the Fever Fly (*Dilophus febrilis*).

The Fever Fly.

(*Dilophus febrilis*).

The following account of this insect is taken from the author's work on British Diptera. *

The imago is black; ♂ shining black; eyes hairy; proboscis and palpi blackish. Wings whitish brown along the costa, and the stigma blackish, veins near the costa black, remainder white. Abdomen quite black. Legs black; tibia at its base armed with a circular row of thick spines, one very large. The edge of the tibia has also a pair of spines and one single one developed on the anterior legs; femora hairy and broad in the anterior legs, narrow in the posterior; metatarsal short, second and third tarsal joints small, with a few larger bristles; last joint long and rounded at the tip, finely hairy; ungues long and dark; pulvilli three and yellowish, the edges apparently striated. The female has blackish-brown wings, paler along the head border; stigma and veins almost black. Eyes not contiguous as in the male. Abdomen brown. Length 2 to 3 inches. Walker says concerning this species that it is generally distributed "in profusion everywhere—most so on sandhills. Appears in conservatories even during severe frost in the middle of winter." This latter statement I cannot verify. This 'fever-fly', which is two-brooded, occasionally appears in vast swarms. It appeared amongst the hop-cones at Rainham in Kent, in 1882. "It has been observed in enormous numbers off the Norfolk coast. In 1862 it was recorded as hanging in millions on flowers and in bunches on grasses" (Ormerod, "Injurious Insects"). In April 1884 Miss Ormerod had the larvæ sent her from Sittingbourne, where they

*An "Account of British Flies (*Diptera*)", 1893.

were attacking hops and doing considerable damage by eating away the roots. They also appear to damage the roots of grass and corn and garden plants. Curtis also notices that the maggots are found in cow and horse manure. I have myself bred them from the latter and think it most probably their true home. If so they are readily spread, in manure, to the fields and gardens, as so many other insect pests are. The first brood appears in May and June, the second in the autumn. The larvæ are white, cylindrical, legless grubs, with brown head and numerous hairs, about a quarter of an inch in length. The pupæ are pale brown; whitish according to Miss Ormerod.

Brachycera.

Amongst the Brachycera or those flies with short antennæ, generally composed of three joints and a terminal bristle, we find many extremely interesting forms, but only one that can be called an insect pest (the Gad Fly), although others occasionally are exceedingly troublesome to travellers. One of our most beautiful British Diptera, namely, the Giant Robber-fly (*Asilus Crabroniformis*), also belongs to this division. The Family *Asilidae* are large conspicuous hairy insects, with prominent separate eyes and stout hairy legs. These Robber-Flies are very bold, they feed upon other insects, sucking away their blood, sometimes even attacking a Dragon-fly and destroying it. The Giant Robber Fly measures nearly an inch in length, it has a long tapering yellow body with the basal half of the abdomen black and with reddish legs. The wings which are large are also deeply tinged with yellowish-brown. Their larvæ which live in damp earth are not sanguinary creatures, like their parents. Another species

in America feeds on honey bees (*Tranpavea Apivora*).

The *Stratiomyidae* or 'chamæleon' flies contain some interesting larvæ, which resemble in many respects those of Eristalis. The flies of this family, of which the 'chamæleon fly' (*S. chamaeleon*) is a member, are often bright coloured, others are black; all have a very flat body and long antennæ or horns. You nearly always see them near water, but they may wander far off to various flowers, where they prey upon other insects; for this chamæleon fly, as others of its family, is carnivorous, killing large numbers of small insects and sucking their juices. The peculiarity I want to draw your attention to is the curious maggot of this fly. It is a long creature, with small head, armed with two hooks which are really mandibles: the posterior extremity of the maggot gets gradually smaller, each joint fitting into the one before it like a telescope; the last joint is perforated by two orifices, which are surrounded by hairs. The orifices are for taking in air, as is done in the 'rat-tailed' maggot. They live in shallow water, and when they want to breathe they shoot out the tail until it is above the water, and when enough air is taken in they sink again to the bottom. After a variable period of maggot life, the grub comes to the surface and floats as an immobile mass; now if you cut open one of these you find a true pupa inside this old maggot skin, which forms a kind of cocoon, and also acts as a boat, for the fly, which soon escapes.

Fig. 42. Stratiomys chamæleon.

Tabanidæ or Gad Flies.

We now pass on to the interesting family of 'gad' flies

(*Tabanidae*). They are most objectionable flies on account of their biting habits, settling upon horses and sucking their blood; in the New Forest they are sometimes very troublesome, but never to such an extent as they are on the Continent. In Switzerland I have seen white horses streaming with blood produced from the wounds caused by one of these gad flies. The parts of the mouth are turned into a sharp sword-like piercing organ, which they thrust into the animal and draw out its blood. The life history is as follows: the female lays her eggs on the grass, and the maggots burrow under the soil. The larvæ are not blood lovers; they are large yellowish maggots, cylindrical in form, and marked with transverse black bands, quite legless, and feed upon vegetable matter. They change to immobile nymphs, which you can distinguish by six spines on the last segment. It is the female fly that attacks animals and man, the male is not nearly so savage; the warmer the day and the brighter the sun the more the females attack the horses. They produce a loud buzzing noise, which often so frightens animals that they rush madly about to try and avoid the insect.

These gad flies are found in all parts of the world, and their habits are very similar. They have a large, broad, depressed abdomen and a very broad head, closely united to the thorax. There is no doubt that various cattle diseases, especially anthrax, are distributed by these insects. Man also has been known to die of anthrax caused by the bite of one of these flies. A smaller species, (*Chrysops*) with black and yellow markings on the abdomen, the males having dark wings and the females transparent ones banded with black, is another sharply biting insect; both sexes have beautiful golden-green eyes with purple dots and lines. They are also very troublesome in woods, settling on the hands, face and neck, and biting very fiercely.

Proboscidea.

The remaining important families belong to the second section, the *Cyclorrhapha*, which is divided into two sub-sections of which the *Proboscidea* is the most important. The Hover or Breeze Flies (*Syrphidae*) are one of the most abundant groups, and one of great importance to us economically. The *Syrphidae* are all moderate sized flies, often brilliantly coloured and delighting in warm, sunny weather, when they may be seen, hovering and darting about in the air and over flowers. The typical *Syrphidae* are included in the genus *Syrphus*, which are readily known by their mode of coloration, most being black or metallic green, marked with yellow or orange bands across the abdomen; these bands may often be interrupted in the middle. The Hover-fly deposits her eggs on leaves, amongst the 'plant lice' or Aphides; the ova hatch into the small yellow, green or red maggots, which are so commonly found amongst the 'Green fly' and other species of Aphides. These *Syrphus* larvæ feed solely on these terrible scourges of vegetation and devour them in enormous numbers. They should therefore always be encouraged in gardens and hop-fields and wherever the Fly is present. Our largest members of this family belong to another genus known as *Volucella*. The *Volucellae* are large, hairy flies, which have black, yellow, white and reddish colours upon them; a few are, however, almost naked. They lay their eggs in the nests of social bees; particular species having their own particular kind of host. *V. bombylans* visits the nests of the Humble-bee (*Bombus terrestris* and *lucorum*), *V. zonaria* the nests of various wasps, and strange to say these parasites mimic the appearance of the insects they live in company with; bombylans looking like a small hairy humble-bee, zonaria

adopting the garb of the wasp. The eggs are laid in a cell of the comb in which a larva is present; as soon as the Volucella larva is hatched it commences to devour the true occupant of the cell, eventually turning to a pupa in the same place.

The *Eristalidae* are a curious genus of flies called 'rat-tailed flies,' on account of the curious form of the maggots. These rat-tailed maggots are found in the water, the dirtier the better, and they may even be found in salt water, such as the brine ponds near salt works. The grubs are cylindrical, and there is a distinct head with two eyes; the posterior end of the body is produced into a long tail, which is perforated by air holes through which the maggot breathes. There are small fleshy swellings on the under surface of the maggot, and by means of these so-called feet they crawl along the bottom of the shallow water.

When they require air they raise up this tail until the openings are out of the water, and then take in the air. The apertures open into tubes, which are connected with the true air tubes (tracheæ), just as the air holes (stigmata) are. This tail is moveable, and can be elongated at will by the larvæ.

There are a good many of these *Eristalis* flies found in England, and one of the commonest is *E. tenax*, the common rat-tailed fly. They are large insects, and have usually a blackish brown appearance, with rusty marking on the abdomen. A large number may always be seen in the autumn upon flowers of all kinds, and they may even continue on to the middle of November or beginning of December.

The Oestridæ or Warble Flies.

Unfortunately it is a very common thing to frequently see the back and flanks of oxen covered with large, tumorous

looking swellings, or 'Warbles' as they are commonly called. These lumps are due to the 'grubs' of one of the *Oestridae*, a family of parasitic flies. These Warble Flies may be grouped into three divisions, (i) the *cutaneous* or those that live during their larval life beneath the skin of animals, (ii) the *gastric* or those that live within the alimentary canal of animals, and (iii) the *facial* or those that live in the head of animals. These flies are good-sized hairy creatures, resembling in appearance a small humble bee, and they are usually brightly coloured with bands of yellow, red and black, others are almost wholly golden yellow. The adults do little harm, their mouths being quite rudimentary; the imago simply living to deposit her eggs. The most typical species is the 'Ox Warble' (*Hypoderma bovis*) which produces the 'bots' or 'Warbles' in oxen mentioned above. The adult fly is a gaily coloured insect, covered with thick hair and banded with yellow, black and red on the abdomen, and with yellow and black markings on the thorax. The head is large and broad. The Ox-Warble loves the hot and sunny days and may be heard buzzing in the air, during the warmest part of the day, and terrifying the cattle. Suddenly we see the cattle stampede across a field to some shelter or shade, then we know that either the Warble Fly or Gad Fly are pursuing them. The former for the deposition of her eggs, the latter to draw out their blood. The Warble Fly settles upon the backs of the oxen and deposits her eggs. Whether she inserts them under the skin by means of her ovipositor or whether only on the hair, is at present a disputed point. In either case the maggot when quite young is found beneath the skin. These flies appear in the summer and the maggots as small thread-like creatures are hatched from the ova during the latter part of that season. They,

however, give no sign of their presence until some months are over—then a small swelling appears, which gradually grows and a small orifice bursts at its summit. Prior to the bursting of this orifice the maggot had fed upon the blood in the soft hypodermal tissues underneath the hide. By degrees violent inflammation and ulceration is set up and causes the wound to burst. The 'bot' or grub present beneath this fleshy lump is at first smooth, but after the 2nd moult it becomes covered with bands of prickles and thus causes the irritation, resulting in inflammation and the bursting of the 'Warble' cell. If we examine this cell or depression where the grub lives, we shall find that it is swollen out at one side into a kind of sac. The grub has its tail towards the orifice and breathes by means of the two stigmatic openings on the tail.

When fully grown the 'bot' squeezes its way out of the cavity, through the orifice, and falls to the ground. The larval skin then hardens and forms a kind of case or puparium around the 'grub', which then turns into the pupal stage. These puparia are found beneath rough lumps of earth and under tufts of grass, and hatch during the summer into the perfect fly. The damage done by this insect is very great, but luckily precautions that are now taken by farmers and graziers have lessened the amount of loss. The chief damage is to the hide, which is spoilt by the perforation caused by the bot. Damage is also done to in-calf cows by causing them to tear about when the fly is present. Loss in condition of course is concomitant with the presence of these bots in the flesh and even death has often been caused where abnormal numbers are present. The damage to the hides can be saved by destroying the bots, directly we can get at them, that is directly the 'Warbles' burst.

Any thick grease daubed into the orifice will fill up the stigmata of the bot and destroy it. *Mercurial ointment* is better than grease, as it not only kills, but in a few days drys up the maggot, which would otherwise putrefy in the cavity. If the grubs are left in until they can be squeezed out, little or no good is done, as the damage to the hide is past repair.

As an example of the *facial type* we may mention the 'Sheep-nasal Bot' (*Oestrus ovis*), which terrify the sheep so much. The eggs are laid on the nose and the maggots pass up into the nasal passages and cause intense suffering. They are even known to have entered the brain. When the grubs which attach themselves to the mucous membrane of the nasal passages by a pair of hooked mandibles, are fully fed, they leave go their hold and are sneezed onto the ground during one of the violent sneezing fits, which is one of the characters of the presence of these bots in the animals. They then turn to puparia in the same way as in the Ox-Warble.

The horse bot fly (*G. equi*) (Fig. 43) which we may take as the third or gastric type, lays its eggs on those parts of the horse which the animal is in the habit of licking, and attaches them to the hair by a sticky fluid; they are licked off by the horse, and hatch, and are swallowed into the stomach, and become attached to the walls by a pair of hooked mandibles. They pass out of the stomach to the ground before they change to pupæ.

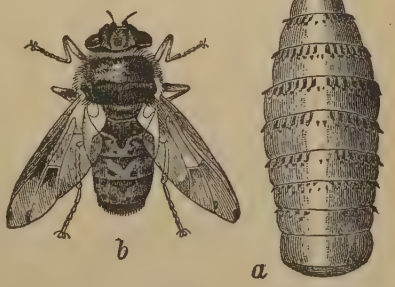


Fig. 43. *Gastrophilus equi* and Larva.

There are many other Bot-Flies attacking various animals and in various ways. They are found in nearly all parts of the world, except New Holland. The most northernly species is one that attacks the Reindeer.

Muscidæ.

Our common House-fly (*Musca domestica*) and the dreaded Tsetse-fly (*Glossina norsitans*) of Africa, together with the Blue-Bottles (*Calliphora*) and beautiful Green-Bottle Flies (*Lucilia*), belong to the family of *Muscidae*. The House-fly, a grey species with the abdomen more or less yellowish in the male and darker in the female, is only too abundant in all houses in summer and autumn, and even may be met with in warm places, as some of the London restaurants, during the middle of winter. In their maggot state the house fly lives in dunghills. The house-fly is subject to a widespread disease; it is very common to find them dead and sticking to the walls and window panes by a film of white tissue. This white tissue is the mycelium of a parasitic fungus, scientifically called Empusa Muscarum, which germinates in the body of the fly and finally causes its premature death. Few travellers in Africa are not acquainted with the terrible Tsetse Fly, a brown insect, somewhat larger than our common house-fly, with a yellow striped abdomen. Although the bite of this pest often causes the death of horses and oxen a few days after by blood poisoning, it appears to be comparatively harmless to man. All the Muscidæ have few bristles only on the body and these present chiefly at the tip. Another extensive family resembling many of the Muscidæ is the *Anthomyidae*, which includes the well known Cabbage-flies and Onion-flies.

Anthomyidæ.

All the members of this genus are dull insects, armed with many hairs and bristles. Many kinds are found indoors in spring, and much resemble the house-fly, and large numbers of others bother us by flying round and round our heads out of doors and trying to settle on our faces. But the only three I wish to call your attention to are the 'root' fly (*A. radicum*), the cabbage fly (*A. brassicae*), and the raddish fly (*A. floralis*); because these are three that do so much damage to cabbage crops. They are usually known as 'cabbage and turnip root maggots,' and these three at least are amongst the number that do the damage. The maggot of the cabbage fly is white and cylindrical, tapering to the head and having a row of teeth on the lower surface at the anal end. They live in the cabbage roots, in swellings which they produce, and the lower part of the stalk, where they form passages and cause disease and decay in wet weather. They pass into the earth to change to puparia, which are brown bodies with black spots formed by the larval skin, and in which is found the true pupa. They go on appearing all the year, as there are several successive generations. The fly, which is ashy grey, hatches in three weeks; the male fly is darker than the female, and has a black stripe down the abdomen and three on the thorax. They attack turnips as well as cabbage. The root-eating fly (*A. radicum*) has much the same habits, but the maggots are yellowish, with two dark brown points at the end of the tail. The pupæ are *paler* than those of the cabbage fly, and the abdomen of the fly itself is pointed, not rounded as in the cabbage fly. They are abundant as well in dung. The radish fly (*A. floralis*) has a curious spiny maggot.

To stop the attack of these maggot pests, you must never use *new* and *rank* manures, for they are really hot-beds of these maggots.

You must not continually grow cabbage on the same ground; change the crop yearly. The rotation of crops soon gets rid of this pest.

Puddling or dibbing the roots at planting with soot and water or lime are also useful to prevent attack. Dressings of gas-lime, which makes the ground obnoxious to flies and maggots, and increases at the same time the action of any manure, is a good method. *The gas-lime must not be used too strong.*

The Onion Fly.

(*Phorbia cepetorum*).

Another fly closely related to the above species is the Onion fly. The maggots cause the 'rot' in onions, where they live and feed until the pupal stage is reached, when they enter the earth to metamorphose. From the pupæ, in about two weeks, an ashy coloured fly with black bristles and hairs, white face and black antennæ, with three black thoracic stripes and a row of large black spots along the abdomen, in the male, appears; the female being more ochreous and with a yellowish face. They may be found all the year round, and deposit their eggs on the lower part of the onion leaves, whence the white maggots crawl down into the bulb and cause it to decay. Another species known as the Shallot fly (*A. platura*), and closely allied, works in a similar way.

As tending to prevent and destroy these pests, do not grow onions for several years on the same ground, as the pupæ remain in the soil. Dress the land with gas lime to destroy the puparia. Watering the plants with paraffin

and water has also been found beneficial. Growing onions in trenches and earthing up as in Celery is perhaps the best preventative, as by so doing the maggots cannot get near the bulb. Raising all the diseased onions with a spud, and burning should also be done. Disease is known by the yellow appearance of the leaves.

The Carrot Fly.

(*Psila rosae*).

Every gardener is acquainted with 'rusty' carrots. This rusty and diseased appearance of the carrot is due to a small fly, popularly called the 'Carrot-fly', a member of the family *Psilidae*. The fly itself is a small insect, not half an inch in expanse of wings, of a metallic blackish-green colour, with a yellowish head and legs and yellow veins to the irridescent wings. It may be found hovering over the carrot leaves from the early summer to the autumn. The female deposits her eggs as near the root of the carrot as possible. The maggot springing from the egg at once works its way into the heart of the root. These 'rust worms' are white to yellow, legless shiny maggots, which are pointed at the head end and truncated at the tail. They may be found at all times of the year. On drawing a carrot out of the ground they may often be seen sticking half out of their tunnels, which ramify all over the inside of the root and cause the rusty patches, giving rise to the name by which the disease is known. When ready to pupate the larvæ leave the carrot and bury themselves in the ground where they turn to shiny reddish pupæ with two black points at the anal extremity. The pupal life in the summer is about three weeks, in the winter they remain for some time in this condition.

That these flies are attracted by the smell of the bruised

carrot leaves and roots is well known. Great care therefore should be paid to thinning, which should be done as early as possible and the 'plant' covered loosely with fine earth, so as to fill up the spaces caused by the loosening of the ground in thinning. Sprinkling the beds with sand saturated with paraffin is a good deterent to attack, when the plant is young and when the thinning operations are taking place.

The Celery Fly.

(*Tephritis onopordinis*).

A constant complaint in the garden, is the damage caused by the Celery maggot. The leaves becoming blotched with pale patches. The maggot causing this disease gives rise to a small fly, the Celery or Parsnip fly, which belongs to the family *Trypetidae*. Most of this family of flies have their wings banded or spotted with black or brown, especially in the genus *Trypeta*, which are often gregarious in habits. The genus *Tephritis*, to which our celery-fly belongs, is distinguished by its reticulate wings and by the scutellum being provided with from four to two bristles. Most, like the celery-fly, feed upon leaves of plants, but some are destructive to fruit, notably the Orange Fly (*Ceratitis hispanica*), which is very destructive to oranges in the South of France. The Celery-fly infests the leafage of celery and parsnip, but the former crop seems to suffer the most from its ravages. This fly is about $\frac{3}{8}$ths of an inch in expanse of wings and is of a pale brownish appearance, with deep green eyes and with transparent wings mottled with brown. They may be found as early as April flying over the celery, but the majority appear in June. The female fly lays her eggs on the leafage of the celery and from them

hatch small fleshy, legless, white maggots, which burrow or mine the leaves and cause the white blisters so often seen in our gardens. The blister gradually turns brown, and when many are present the plants are often killed. When fully fed the maggots turn to pupæ, either in the leaf or in the ground, within the old hardened larval skin, forming a puparium. Three or four broods may appear in the year.

After a bad attack it is most desirable to rid the ground of the puparia left in it. This can be done by skimming off the surface and burning it or by dressing with gas-lime. The leaves also should be burnt or otherwise destroyed. Dusting the young plants with soot and slacked lime or any other substance objectionable to the fly, will be found of much service. Watering the leaves with paraffin and water has also been found successful by the author; a wineglass of the former to a gallon of water. Creosote and carbolic acid in water are also valuable insecticides.

The Gout Fly.

(*Chlorops taeniopus*).

A well known disease amongst barley, usually known as 'Gout' is produced by the small fly, scientifically known as *Chlorops taeniopus*; tæniopus or the Gout fly is a small insect, not more than $\frac{1}{8}$th of an inch long, of a thick build, with three black stripes on the yellow thorax and with a greenish-brown abdomen marked with black bands, When the ear of the corn is still in its sheathing leaves, the fly deposits her eggs, either within the sheathing leaves or so that the maggot can readily pass into them. The maggot then destroys a few of the developing grains on one side and then mines a tunnel down the stem to the

first node, where it eventually turns to a brownish-yellow puparium. When the plants are badly nourished, the result is a stunted growth, the ears being unable to burst through the sheathing leaves, resulting in a curious swollen or 'gouty' appearance of the whole plant. When well nourished the barley may outgrow this disease and burst the sheathing leaves, it then shews a long black tunnel down the stem from the ear to the first node. This is the case in the usual summer attack, but in Germany a winter attack is also prevalent.

Early sowing again is a great preventative for this disease. The fly also lives upon grasses and it has been noticed that it is more abundant near grassy headlands, which should therefore be cut low or burnt in the winter. It is also noticed that the worst cases of attack take place in badly manured lands and that when top dressings of soluble manures are applied to infested crops, that they so far recover as to save at least $\frac{2}{3}$rds of the crop. The winter brood of this fly is found upon various wild grasses.

Eproboscidea.

There are many other families of diptera of great importance, but space will not allow even a short reference to them here. A few words, however, must be said upon the wingless parasitic diptera, the *Hippoboscidae*, *Nycteribidae* and *Braulidae*, which are united under the term *Eproboscidea*. The Eproboscidea resemble spiders in appearance more than flies. They are all parasitic and are remarkable for the perfect insect producing its young singly, not as an egg, but as a pupa, or mature larva. The well known Forest Fly (*H. equina*), a brown species, about $\frac{1}{3}$rd of an inch long, attacks horses, creeping under their bellies and sucking the blood, causing great irritation. This species

has sometimes been very abundant in the New Forest. Others attack birds, living beneath their feathers. Wingless forms are abundant; the common Sheep Tick (*Melophagus Ovinus*), which is a wingless fly and not a 'Tick' at all, is an example and may be found abundantly amongst the wool of sheep. The wingless *Nycteribidae* are parasitic upon bats; whilst the *Braulidae*, are small, blind, wingless, reddish-brown insects, known as bee lice, found parasitic upon our hive bees.

CHAPTER VIII

HEMIPTERA OR BUGS AND APHIDES

Genera Account—*Homoptera*—Cicadidæ—Fulgoridæ—The Hop Frog Fly—Plant Lice or Aphides—American Blight—Snow-flies (Aleyrodidæ)—Scale Insects (Coccidæ)—The Mussel Scale—*Heteroptera*—Scutellaridæ—Lygæidæ—Cimicidæ—Reduviidæ—Gerridæ—Nepidæ—*Anoplura* Lice.

THE Hemiptera are a very interesting group of insects including the Bugs, Plant-lice, Lantern flies, Scale Insects and Cicadas. The majority of the Hemiptera live upon vegetation, but some will be found to be carnivorous. On the one hand we get the vegetarian hemiptera most injurious to our crops, on the other we get them most useful and beneficial to us, the Plant Lice may be mentioned as an example of the former and the Cochineal Insects and Lac Insects of the latter. The mouth of these hemiptera is formed for piercing and sucking; it consists of a jointed rostrum, made up of an elongated labium, which forms a jointed sheath for the sharp styliform mandibles and maxillæ. There are ocelli present as well as compound eyes. Four wings are the rule, but they may be absent or reduced to two, as in the male scale insects. The Hemiptera undergo an incomplete metamorphosis, that is to say the difference between the larva, pupa, and imago is very slight, the pupæ being active creatures. The larvæ, which resemble in most respects the adult, moult or cast

their skin a number of times. After one of the moults, rudiments of wings may be seen, the pupal stage is then reached; the only difference between the larva and pupa, being this presence of rudimentary wings in the latter. In due time the active pupa casts its skin and the fully winged adult appears. The eggs of these insects are often beautifully sculptured objects and are deposited upon leaves and in the aquatic families on water plants and stones. The Hemiptera are divided into two well-defined sub-orders, the *Homoptera* and the *Heteroptera*. The former group which includes the Plant Lice, Cicadas, Lantern Flies and scale insects has four membranous wings and the beak or rostrum attached to the frontal region of the head. The *Heteroptera* or Bugs, Water Scorpions, etc., have the basal part of the front wings horny or leathery and only the apices membranous, and the rostrum springing from beneath the head. There may also be a third sub-order, namely the *Anoplura* or *Pediculidae* (Lice), which are often considered as degraded homoptera. These have no wings at all and are all parasitic.

Homoptera.

The homoptera contain eleven or more families, some of the tropical members being large and beautifully coloured insects, but most of our British species are small and inconspicuous. The exotic *Fulgoridae* or Lantern Flies and *Membracidae* assume the most curious forms, no words can describe the varied and monstrous appearance of the enormously developed prothorax of the latter family. Whilst the *Cicadidae* (Fig. 44) assume gigantic proportions. Not only is this sub-order of great interest to us from the varied appearance and habits of its members, but it is of great economic importance, for it contains the destructive

Plant Lice (*Aphidae*) and the Frog Hoppers (*Cercopidae*) also the valuable Cochineal Insects (*Coccidae*), which have also unfortunately many injurious species (Scale Insects) related to them.

I shall pass over the important exotic family of *Cicadidae*, as our fauna only includes one species *C. anglica*, which reaches an inch and a quarter and is

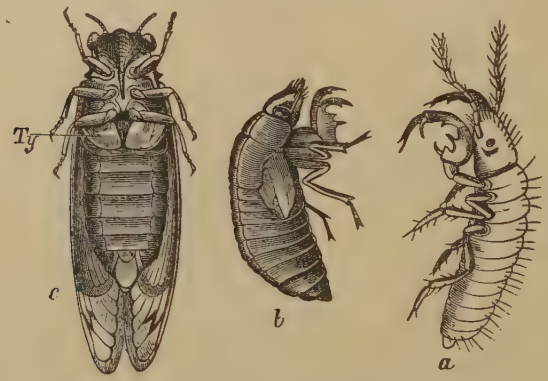


Fig. 44. *Cicada orni*, *a* larva, *b* pupa, *c* imago.

our largest Homopteron. In America they do much damage, one species *C. septemdecim* is said to appear every seventeen years in abundance, the young larvæ feeding at the roots of the oak and apple and, doing much damage. They live for seventeen years and, according to Packard, they appear in different broods, so that some are always present in some part of the country. All the Cicadas are noted for the curious chirping produced by the larger species, the males being armed with large and conspicuous drums (*Ty*) on the abdomen for producing the sounds. The typical *Fulgoridae* or Lantern or Candle flies are unknown in England. The South American Lantern Fly (*F. Laternaria*) is the largest Homopteron after the

Gigantic Cicadas. It is three inches long, and nearly five in expanse of wings. The head bears an immense hollow projection in front, which bends upwards at half its length and is then continued forwards, the end being rounded. Many of these Lantern Flies are said to produce a brilliant light, but this still seems doubtful.

Everyone acquainted with the country will have noticed a curious white frothy spittle upon the wild plants during the summer. This spittle or 'Cuckoo Spit', as it is popularly called, is produced by one of this order of insects. If you remove the froth you will find buried in it a greenish-yellow larval homopteron, which is the larval stage of the Cuckoo Spit (*Aphrophora Spumaria*) belonging to the family *Cercopidae* or the 'Frog-hoppers'. This family resembles the Cicadidae, four large wings are present, the front pair often being faintly coloured; the antennæ placed just in front of the eyes, are 3-jointed and terminate in a bristle. They have their legs adapted for leaping, the hind ones being either spineless or with two to three spines in a single line.

The Hop Frog Fly.

(*Euacanthus interruptus*).

If you tap the hop-bines when walking through a hop garden, you are almost certain to frighten off some active little hopping and flying insects known as Frog Flies or 'Jumpers', these are scientifically known as *Euacanthus interruptus*. They are yellow, variously marked with brown or black, the upper wings having usually a long brown triangular mark from the tip to the centre and another brown mark running along the hind border. The female lays her eggs upon the bines and the poles and these

give rise to the young larval 'Frogs', which are fully developed by July or the latter part of June. They attack the leaves of the hop and I notice that they generally prefer the young and tender apical leaves. When present in large numbers they often do much damage and turn the whole plant yellow. They are generally caught in the hop gardens by means of tarred boards held between the 'hills' and then tapping the bines, these Frog Flies jump off on to the trap below. Much good can be done when this pest has been present in stopping its recurrence by having the poles thoroughly cleaned in the winter and the bines burnt, so as to destroy the eggs.

The Plant Lice or Aphidæ.

Few insects are better and more universally known than the *Aphides*. Their destructive nature manifests itself in every garden, greenhouse, and field in England, few plants being immuned from their attack. There are some three hundred species found alone in our country, most having their own particular food plant. The 'Fly', as they are often called, are mostly brown and green, soft fleshy creatures, with swollen bodies, and may or may not be winged. The wingless (Fig. 45, *b*) forms being usually found in the asexual generations. The tarsi are 2-jointed, and their antennæ long and composed of 5 to 7 joints, their transparent wings have few veins in them. The head of these 'Dolphins,' as they are called in Kent, is united closely to the body and bears a pair of compound eyes, but no ocelli. The mouth is a true piercing and sucking organ, and with this sharp proboscis the damage is done to the plants. The fleshy swollen abdomen has upon its dorsal surface towards the anal end two tubes or cornicles, these tubes are for the ejection of 'honey-dew'. This honey-dew

is a sticky, sweet fluid excreted by the Plant Lice or 'Smother flies' (another name by which they are known), most abundantly during warm weather; we can notice when sitting under the lime trees when they are in flower, a constant dropping of a sticky and sickly fluid, this is the honey-dew exuded by the 'Blight' upon the lime trees, and we shall also notice the shiny sticky appearance of the leaves, often turning black from the excreta of the

Fig. 45. Cherry Louse (*Myzus cerasi*).
a. Winged viviparous ♀. *b*. Wingless viviparous ♀.

Plant Lice sticking to the gummy liquid. This honey-dew is much sought after by ants and it is said that the latter keep a certain number of the Aphides as milch-kine. The male Aphides are always winged but the females may or may not be.

During the summer most of the females are apterous, but at certain times and always in the autumn the winged females (Fig. 45, *a*) appear. One of the most curious features in these insects is their rapid and curious

manner of reproduction. The females (wingless and winged) in the summer produce living young, without the intervention of the male element; this non-sexual reproduction is known as *parthenogenetic reproduction* and is met with in a few more cases in the insects. The wingless female (Fig. 45, *b*) that appears in the spring, either having hibernated or hatched from an egg, as soon as she has settled upon her favourite plant, commences to produce living young, which likewise go on producing other living young like unto themselves. This may go on for eight or nine generations, and as each female originally produces some hundreds of young, it can readily be seen what enormous numbers of Aphides can be the result of a single Plant Louse upon any particular plant. It has been calculated that one female will give rise to a quintillion of young in the year. This rapid increase causes them to become too crowded upon the original plant, and then winged females make their appearance and fly off to 'fresh fields and pastures new', to spread the disease. This continual stream of non-sexual production goes on until the autumn, when the true winged males make their appearance for the first time and fertilize the females which are generally winged and are called oviparous females.

The result of the sexual connection is the production, not of living young, but of ova. Thus we get viviparous and oviparous females. The eggs may give rise to young that year and they may hibernate or they may remain as ova until the following spring. The metamorphosis of these 'Dolphins' is of course incomplete, the larvæ and pupæ exactly resemble the wingless females; but when winged forms are to appear, the active pupal stage may be told by the rudiments of wings appearing at the sides of the thoracic region. There are, as a rule, certain differences of colour between the larvæ or lice, the pupæ and the adults. In all three stages they are covered with

a mealy substance that repels water. Some of our worst pests belong to these insects, notably the Hop Aphis or Hop Dolphin (*A.* [*Phorodon*] *humuli*) which causes such terrible blights in our hop gardens. Other important species are the Bean Aphis or 'Collier' (*A. rumicis*), a black species clustering at the heads of the Broad Bean and blackening and destroying their summits, the Corn Aphis (*Siphonophora granaria*) found upon wheat, barley, oats and rye, sometimes shrivelling the grain to a very serious extent. Turnips also in some years suffer largely from the green fly (*A. rapae* or *Rhopalosiphum dianthi*) present on the under surface of the leaves, and one of our worst fruit pests is the American Blight or Woolly Aphis (*Schizoneura lanigera*) belonging to this group.

American Blight.

(*S. lanigera*).

The attack of the 'Apple-bark Louse' or 'Woolly Aphis', may readily be detected by the white cottony growth on the insects, formed by an excretion, giving the appearance of a white film at the bottom of the crevice, where the insects hide. Sometimes this cottony growth hangs down in great festoons. These aphides have no cornicles; the third vein of the wing is forked. In the true Aphides (*Aphidinae*) this vein has two forks, whilst in the third section, the *Chermisinae*, this vein is absent. The adults are slaty grey and the larvæ reddish. They are spread from tree to tree and orchard to orchard, in the cottony growth wafted by the wind. The result of their presence on the trees, is the too often seen diseased and swollen growths on stem and shoots. Most are wingless forms, but winged ones appear in July and August. They

always prefer to fix upon some wound or cut surface for their new home, so that they can readily pierce the soft tissue with their tender beaks. So important is this Apple pest that a few notes upon destroying may well be given.

One of the most necessary points in the prevention and destruction of this Blight is to keep the tree clean. The aphides harbour and breed under and amongst the rough bark, and, by destroying and scraping off this, much of their shelter is done away with. It is also most desirable that the trees should not touch one another, and be kept in decent order, so that a free circulation of air and plenty of light reaches every part of the tree. Painting the trees with thick washes of soft soap, lime and sulphur will be found most advantageous, and when present to a serious extent, a thorough drenching by garden engine with soft soap and quassia or tobacco juice. This blight is said to affect the roots also and does, no doubt, much harm there. I have, however, never been able to discern any *lanigera* on roots. Numbers of lice have been sent me and all belong to two other totally distinct species, *viz*, *S. fodiens* and *Pemphigus lactucae*. The great vine pest in France, the well known *Phylloxera Vastatrix*, attacks both roots and shoots, on which they produce small galls. It also belongs to the family of Aphides. Many others also live in two forms, one upon the shoots and another on the roots.

'Snow Flies'.

(*Aleyrodidae*).

This family of homoptera strongly resemble small moths, both sexes have four opaque wings of nearly equal size, covered with a white powder. The pupæ are inactive

and are enclosed in the dried skin of the larva. The common species, the 'Cabbage Powdered-wing' (*Aleyrodes proletella*), is often abundant on various members of the *Brassica* tribe, nearly all the year round and I have also seen them in clouds amongst the Ilex when beaten. These snowy white insects attack the leaves in their larval state and cause them to become blotched with brown or yellow. The female lays her eggs on the leaf, these quickly hatch (ten days) into larvæ, which shortly cover themselves with a white scale with two yellow spots, and are fixed beneath to the leaf by a sucker. Under the scale they turn to a pale chrysalis with red eyes, and from this the Snow-fly hatches in about four days. All cabbages affected with this pest should be pulled and destroyed, and not thrown on the rubbish heap so that the larvæ can develop in safety.

Scale Insects.

(*Coccidae*).

The family of Scale and Cochineal insects or *Coccidae* is closely related to the Aphidæ. The scales are particularly interesting as far as their development goes and their curious life history. They do not progress regularly as do the Aphides, for after the pupal stage is reached they retrograde, instead of develop, in a most remarkable manner in the female sex. The larvæ are six-legged active creatures which eventually fix themselves upon some particular part of the plant and turn to the pupal stage, gradually the active larva loses its six legs and becomes simply a fleshy swollen mass, fixed to the leaf or stem by its beak. The females are always like this, but the males are winged, most only having two wings. As soon

as the female has been impregnated she lays her eggs and dies. One of the curious characteristics of these insects is that they excrete a waxy substance that forms a scale over the female body and serves as a protection to the ova deposited beneath. When the eggs are laid the female shrivels up and her dried skin also remains as a protection. These scales are not uncommon on the leaves and stems of various plants and often do considerable damage, when present in large numbers. In the males the mouth is usually rudimentary; two anal setæ are generally present at the posterior end. The males are very rare and many are entirely unknown, although we are well acquainted with the female or 'scale' form.

One of our English scale pests is the White Woolly Currant Scale (*Pulvinaria ribesiae*), whilst the Mussel Scale (*Mytilaspis pomorum*) may be found in any old apple trees in immense numbers.

The Mussel Scale.

(*M. pomorum*).

This scale is so called on account of its resemblance to a small mussel shell. It is known in Europe, N. America, New Zealand and Tasmania. These brown scales formed by the insect are nearly $\frac{1}{8}$th of an inch in length. There appears to be a slight difference, chiefly in size, between the male and female scale. Whether the true winged male of this species has been found is very doubtful, at least we have no record of it.

If we lift up one of these brown scales we shall find the full grown fleshy female in the small end of it, while the large end is filled with a cottony growth and a number of eggs. The female is yellowish grey and the body is

plainly segmented. The ova soon hatch into little white six-legged maggots with distinct antennæ. These maggots soon settle down, fixing themselves by their beaks, turn to pupæ and become eventually a scale.

The Currant scale (*P. ribesiae*) which forms large festoons of a white cottony growth on red and black currants, also does much damage to those shrubs on the Continent and now and then in England. The scale of this species is a large raised brown shiny mass, cleft at one end and standing up from the stem. It may be seen in this state during the winter, but in the summer it gives out a cottony secretion, which festoons the trees, and amongst this downy substance the six-legged orange larvæ may be seen crawling.

All scales may be partially destroyed by scrubbing the bark with soft soap and water, to which may be added a little quassia or tobacco juice and paraffin. The trees should also be painted with lime, soft soap and sulphur. If possible they should be scraped well with a blunt knife first. *Resin* washes are largely used in America with excellent results.

Besides these destructive scales, which now and then, as was the case with some of the American orange groves, destroy entire crops year after year, the *Coccidae* include those useful insects which produce Cochineal and shellac. The Cochineal of commerce is really the dried body of the pregnant female of a scale insect known as *Coccus cacti*. Other species producing dye are found in various parts of the world. The 'manna' of the Israelites was also supposed to be due to the agency of one of these insects, known as *Coccus mannipurensis*, which is found on the tamarisk in Palestine and produces a gummy extravasation of the sap, known as manna, and which is eaten by the natives.

Heteroptera.

The *heteroptera* are not nearly so important to us, although many do damage to vegetation and one at least, the Common Bed Bug (*Cimex lectularius*), is anything but a pleasant companion. The heteroptera are of very varied structure and habits. Most are terrestrial and herbivorous, but some are true aquatic insects and have carnivorous habits. Their two semi-coriaceous wings or *hemielytra* at once distinguish them from other insects. Some authors treat them as a separate order, but I think it is best to keep them under the same term as the homoptera. There are some fifteen families in this section, a few only of which can be dealt with here. The first, and one of the largest, the *Scutellaridae* or Shield Bugs (Fig. 46), have a prominent beak, long antennæ, generally 5-jointed. The mesothorax is much larger than the pro- and metathorax together, with the scutellum large or very large, sometimes covering the whole of the wings and abdomen. They are often brilliantly coloured, with red, green and metallic hues. They are popularly called Land, Shield, or Wood Bugs. A common form found on plants and walls is *Pentatoma grisea*, with a large triangular scutellum which does not, however, cover the entire abdomen. The larvæ and pupæ are very similar to the adult. This genus, which has many bright green species, is abundant in Europe. It occasionally feeds upon other insects as well as plants. Many of the *Scutellaridae* have the same peculiar and obnoxious smell as the Bed Bug.

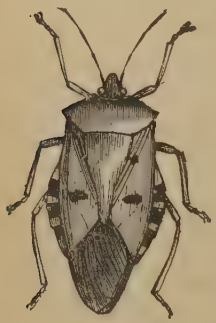


Fig. 46. Shielded Bug.

The *Lygeidae* are characterised by having a small scutellum, 4-jointed antennæ and rather elongated bodies. The 'Soldier and Sailor' (*Astemma aptera*) belongs to this family. They are red and black in colour or slaty grey with red patches, and are found during summer running about in fields and gardens, especially upon stones and rubbish. The wings are somewhat imperfectly made. Several of this family are very injurious to cultivated plants. In the United States a species known as the 'Chinch Bug' (*Blissus leucopterus*), a black insect with white fore wings, each of which is marked with a black triangular patch, is said to often entirely ruin the corn crops. Whilst the tea planters are constantly bothered by the ill effects of the numerous 'Tea Bugs'. One species called by the hop-pickers, the 'needle-nosed flea' scientifically *Anthocoris nemorum*, is said to do much damage at times to the hops. This bug is a small black species with pale elytra, marked with transverse black stripes. A larger species, *Calocoris fulvomaculatus* also has been most destructive to hops. It pierces the bine and causes the sap to flow out.

The generic name *Cimex* was at one time given to all 'bugs', now it is solely retained for those with a broad depressed egg-shaped body and with antennæ tapering to their apex and with generally rudimentary wings.

This genus *Cimex*, which is included in the family *Cimicidae*, the characters of which are the same as given above for Cimex, is represented in England by the dreaded and noxious Bed Bug (*C. lectularis*). It is not a true English insect, but is a native of Africa; its first recorded appearance in England was in 1503, when it caused immense excitement, as some ladies thought its bites were plague spots, and immediately sent for a doctor, who soon caught the 'cause of alarm'. But not until

after the fire of London in 1666 did the bed bug become common and troublesome; they were imported in timber from foreign places to London on the rebuilding of the city. The bed bug does not only feed on human blood, but likes it sufficiently well to be able to crawl from the floor to the ceiling so as to drop down on the peaceful slumberer. They lay their eggs in the dust and dirt and are never seen in clean places; carbolic acid soon drives them out of any holes and crevices where they may linger. They infest animals as well as man, and different kinds are found on them. In Africa winged forms are found in the negro cabins.

Very different in shape and appearance are the members of the next family, the *Reduviidae*, which have a long head, narrowed behind into a neck, large prominent eyes, a thick curved naked rostrum, with slender bodies, legs, and antennæ. All the Reduviidæ are carnivorous and are extremely active creatures, pursuing other insects with great rapidity. They are best known in the type commonly called the Wheel or Masked Bug (*Ruduvius personatus*) a black insect, about $\frac{3}{4}$ths of an inch long and common in out-houses and old disused places, amongst dust and fluff, covering its body with this unclean matter when in the larval and nymph state. The adults fly about in the fields, but return to the houses to lay their eggs. The larvæ and pupæ are both very fond of the Bed Bug and are known to devour large numbers. Some of the foreign species are dreadful creatures; *Conorrhinus Renggeri*, a large black species mentioned by Darwin * attacks travellers camping out, and has a very powerful bite. This family is scattered all over the globe, but is most abundant in warm regions.

The remaining groups of heteroptera are all aquatic and

* "Voyage of the Beagle", Darwin.

solely carnivorous in habits. The family *Gerridae* or the 'Water Measurers' are to be found abundantly on all pieces of fresh water, being represented by the genus *Gerris*, whilst the genus *Hylobates* is truly a marine one. Species of this pelagic genus have been met with running on the seaweed and on the surface of the water, some hundreds of miles from land. The *Gerridae* are all long and slender insects, generally of a black or brown colour. To enable the *Gerris* to live on the surface of the water and to skim in its curious rapid manner over it, the body is shaped like a boat and the middle feet are covered with a close coating of hairs, which repel the water, as likewise does the whole body surface. They can also fly in the adult state, and it is not unusual at sunset to take them on the wing near pieces of water. A strange species belonging to this family (*Aëpophidus*) is found in company with a beetle having similar habits (*Aëpus*) between high and low tide marks on our own and the French coasts.

Having very similar habits to the gerridæ are the 'Water Scorpions' (*Nepidae*). The *Nepidae* have very short antennæ, which are apparently hidden in cavities. Their front legs are raptorial and they have, as a rule, two long processes arising from the tail.

Anoplura.

The true lice or *Pediculidae* are now generally considered degenerate Hemiptera. They were formerly treated as a separate order, in connection with the Mallophaga. They have all suctorial mouths, filiform 5-jointed antennæ and 2-jointed tarsi. The wings are absent, and they are always parasitic. These parasitic lice are nearly perfect when hatched from the egg. They really seem to retain their larval state through life. That a certain

amount of retrograde development takes place in the later stages of the egg is well known. The early embryonic stages are the same as in all other insects, but at the close of the embryonic life, certain curious degenerate features take place. The three common species that infest man are the 'Head Louse' (*P. capitis*) the Body Louse (*P. vestimenti*), found in the clothes, and the Crab-Louse (*Phthirius Inguinalis*) found in the hair of the head and body. These pediculi can reproduce themselves parthenogenetically, generations of females appearing without any male element being made use of.

The eggs are laid on the hair, seldom more than one on each hair and hatch with great rapidity.

CHAPTER IX

ORTHOPTERA

General Account—Cursoria (Earwigs and Cockroaches)—Gressoria (Praying Insects and Stick Insects)—Saltatoria (Crickets, Grasshoppers and Locusts).

THE Orthoptera are not abundantly represented in England, as far as species go, nor, except in the Cockroach and Earwig, do we find an excess of individuals, sufficient to cause any serious amount of annoyance. This order contains the Earwigs, the Cockroaches, the Praying Mantis flies, the Walking-Stick insects, the Grasshoppers, the Crickets and the Locusts. All these are characterised by having the anterior wings of a leathery texture, and much narrower than the posterior membranous ones, which are often large and fan-shaped. The mouth of the Orthopteron is formed for biting, and their metamorphosis is incomplete. They can always be distinguished sexually either by the external genital appendages, or by the size of the body, or by the presence of 'musical apparatus.' The 'chirp' of the 'Grasshopper' is known to every lover of nature. This 'voice organ', to be described later on, is present only in the male in the 'Grasshoppers,' but in certain Locusts, the female also has it perfectly developed. The head of an orthopterous insect bears long, multiarticulate antennæ, as a rule, a pair of large compound eyes and simple ocelli.

The prothorax will always be found to be freely moveable. The young resemble the adult in general features, directly they leave the egg, and in the case of wingless forms, there is scarcely any perceptible difference. They always moult their skins three times, and at the end of the third moult they exactly resemble the creature that came from the egg. The fourth moult takes place and then the rudiments of wings appear, this is then the pupal stage; on the bursting of this skin a fully formed, winged adult is produced. In those that have only very rudimentary wings, no fifth moult takes place. The apterous species only pass through the three successive moults, answering to the larval stage. The metamorphosis is here seen to be very incomplete, in the most advanced we only get a semblance of the larval and pupal stages, whilst in many we never pass the larval period of the higher insects. The colours of the British Orthoptera, which number about thirty, are dull; but in the tropics, where they are very abundant, they are often beautifully coloured. Some of the Grasshoppers even in the South of France are also brilliantly tinted, with pink and blue. This order has been divided into three sections, according to the use of the legs, *viz.*, (i) the *Cursoria* or those with running legs, as the Cockroach, (ii) the *Gressoria* or those with ambulatory legs, as the Stick insects, and (iii) the *Saltatoria* or those with jumping legs, as the Grasshoppers.

Cursoria = Earwigs (*Forficulidae*) and Cockroaches (*Blattidae*).

The Earwigs or *Forficulidae* are sometimes considered distinct from the Cockroaches, and are then known as the *Euplexoptera*. This family has the front wings, or tegmina, very short and leathery, whilst the ample posterior pair are folded beneath them. The abdomen is terminated by

a pair of sharp forceps with which the insect folds and unfolds its wings. Most of the Earwigs or Earwings, as they should really be called, are nocturnal in their habits, some few, however, fly by day. The commonest species is *Forficula Auricularia* (Fig. 47, *a*) or the Common Earwig, which does so much damage to our flowers. All the Earwigs are vegetable feeders, and choose the blossoms of flowers in particular. The one in question is very partial to the *Dahlia;* we can seldom shake a *Dahlia* blossom without some of these insects falling out. They hide away during the daytime, under rough bark and beneath stones, and I have noticed a common habit in them of remaining flattened against the under side of a leaf until the evening. The eggs are laid in little packets. The young larvæ resemble the adult, only no wings are present and they are paler in colour. The female looks after her young most tenderly, a peculiarity not often found in insects. It is said she broods over them as carefully as a hen. Other forms are apterous.

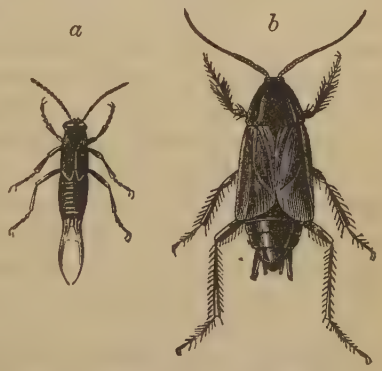


Fig. 47. Earwig (*a*) and Cockroach (*b*).

Few insects have received so much abuse as the Cockroaches or Black-beetles, as they are wrongly designated, by man in all parts of the world. They are members of a family called the *Blattidae* (Fig. 47), characterised by having overlapping tegmina, a hard coriaceous covering to the whole body, which is very much flattened, and by the head being nearly concealed by the prothorax. The

antennæ are very long and the legs are adapted for running which the Cockroaches are very good at. They lay their eggs in batches, surrounded by a tough capsule. In this compact form the female carries them about with her until they are ready to hatch, when the mother helps them out of the case. The young resemble the adults very closely, but are always paler in colour; in some species they may be even pure white. They moult many times, and when rudiments of the wings appear they are said to be in the nymph stage. In warmer climates than ours, Cockroaches are very destructive and even in our own they are often a great nuisance in kitchens and old houses. They are particularly troublesome on board ships and have been spread to nearly all parts of the world in that way. They are omnivorous, there is nothing they will not eat, even to the leather of boots. The two commonest kinds are the *Blatta Americana*, a large species with well developed wings, and *B. orientalis* (Fig. 47, *b*), which has the wings rudimentary. The latter species is the household pest. One of the largest species, the so-called 'Drummer' of the West Indies (*Blaberus giganteus*) is also occasionally found here and several smaller kinds are found in woods and fields.

Gressoria = Praying Insects (*Mantidae*) and Stick Insects (*Phasmidae*).

The Gressoria are a very curious group of Orthopterons, and have excited much interest. The first family or *Mantidae* are usually called Praying Insects, on account of the curious habit they have of resting on their four hind legs, and raising the two front ones in an attitude of devotion. Needless to say, although one is called *religiosa*, they are not going through their devotions, but

are on the alert for their prey. In these insects the body is long and slender and the front legs are thickened and serrated; the prothorax is very long and the head is moveable, with large eyes and sharp mandibles. The wings are large, and sometimes the posterior are prettily coloured. They are all carnivorous and crawl about on bushes, hunting for their prey, where they remain motionless for hours in the curious attitude mentioned above, until some unwary fly passes near, then the almost lifeless Mantis, darts out its front legs and seizes the unfortunate victim, which is speedily devoured. They lay their eggs in capsules, placed upon bushes and trees. The best known is the Praying Mantis (*M. religiosa*), a green species measuring nearly two inches in length.

The *Phasmidae* include the Stick Insects, and the Leaf Insects. All their legs are used for walking. Many of these insects have long, slender bodies and legs, and resemble to all appearance pieces of dried stick. Many are apterous, others have short tegmina and very large posterior wings. The tegmina are generally green, whilst the under wings are often delicately coloured. One wingless species (*Phibalocera pythonius*) reaches the length of eight inches, and exactly resembles a shoot of bamboo. Others have an unpleasant habit of squirting out an acrid poison when disturbed (*Lopaphus cocophages*); some of the African species are said to be able to eject this fluid as far as four feet. The true Leaf Insects (*Phyllium*) are peculiar for the curious modifications, not only of the wings, but also of the legs. They are broadened out and resemble leaves and when resting upon some plant are most difficult to see. Many *Phasmidae*, which are tropical insects, although a few are met with in S. Europe, measure as much as nearly a foot in length.

Saltatoria-Crickets, Grasshoppers and Locusts.

The Saltatoria are true jumping insects. They are characterised by having the hind legs long and the femora thickened. The three families which compose the Saltatoria are the *Achetidae* or Crickets, the *Gryllidae* and the *Locustidae* or Locusts and true Grasshoppers. The Crickets are characterised by their wings being laid flat over the back and often projecting beyond the abdomen; the latter is furnished with two setæ, as well as the ovipositor in the female. Their tarsi are usually composed of three joints. The cheerful chirp of the House Cricket (*Acheta domestica*) is known to all of us, although this brown species, so abundant in houses, is seldom seen. It hides itself in holes in old walls and chimneys and only appears at night, all the Crickets being nocturnal in habits. The Mole Cricket (*Gryllotalpa vulgaris*) lives under the ground and very rarely leaves its burrow. The body of this species is almost cylindrical, and their feet and legs are thick and short and are wonderfully adapted to scraping in the earth. They burrow first a deep vertical shaft, and then mine away horizontally from each side of it. These galleries sometimes go for great distances, the moles working through all roots that come in the way, and as they prefer made soils, such as we find in gardens and vine borders, they often do much damage. Although not very abundant in England, they should be kept down as much as possible. Some of the New Zealand 'Crickets' reach the length of five inches (*Deinacridae*) and are found crawling up trees.

The *Gryllidae* (Fig. 48) have long antennæ, and differ from the Crickets by the wings being roof-shaped when

folded and by the tarsi being 4-jointed. Most of these 'Jumpers' have well developed wings, but some species have them only in a rudimentary state. In all cases the male has the front pair modified in certain parts as sound producing organs. At the base of the tegmina there is a space covered by a thin transparent membrane, and it is situated between some twisted and enlarged nervures. When the male wishes to drum, the wings are elevated and are rubbed one upon the other, and produce the chirping sound by the vibration of this thin membrane. The Grasshoppers can fly well and often travel great distances, but their usual mode of progress is by repeated leaps. The female lays her eggs in the earth by means of her long sword-like ovipositor. The most conspicuous British species is the Great Green Grasshopper (*Phasgonura viridessima*), which measures nearly four inches in expanse of wings. The third family of the Saltatoria is the *Locustidae* or Locusts and true Grasshoppers, which are often of a very destructive nature. They have short antennæ, with large wings extending along the sides of the abdomen; the ovipositor is rudimentary and the tarsi 3-jointed.

Fig. 48. *Gryllus campestris.*

Most of our common Grasshoppers, seen in our fields and downs belong to this family and are quite harm-

less; they are generally green and brown in colour or reddish and are usually about an inch long. They belong to the genus *Rhammatocerus*. Some beautiful species of the genus *Œdipoda* are found on the Continent. The tegmina being brown, whilst the hind wings are blue, red or yellow. These brilliantly coloured insects may easily be mistaken for butterflies when flying. Locusts are sometimes found in England, but they are not indigenous to this country; they are, however, abundant on the Continent and in warm climates, where they often do much damage, travelling in large armies and sweeping all vegetation before them, leaving plague and famine behind. They lay their eggs in the ground in tunnels and close them up. The young are like the adults, only small and wingless. The sound is not produced by organs on the wings, but by a curious modification of ridges on the femora of the hind legs which are rubbed against the wings and produce the stridulating noise.

CHAPTER X

THE NEUROPTERA

General Account—Neuroptera-vera—Pseudo-neuroptera—Thrips—Mallophaga or Bird Lice—Thysanura and Collembola.

THE *Neuroptera* form a very diverse order of insects, it is scarcely possible to lay down any definite characters common to all its members. Many of the insects now included in this order were formerly considered separate orders; it is far better that we should simplify the primary classification as much as possible and hence several of the old orders of insects, such as the *Trichoptera* and *Thysanura* are sunk under the one primary group or order Neuroptera. As a rule the Neuroptera may be said to have four wings of the same texture, with numerous veins and cross veins, giving them a peculiar lace-like or reticulate appearance; the mouth is masticatory and is furnished with strong mandibles as a rule. The female rarely has a conspicuous ovipositor and is never armed with a sting. The larvæ are active hexapod creatures; the pupæ may be active or quiescent, metamorphosis complete or incomplete, generally the latter. The members of this order live in very different manner, some, as the Termites or White Ants, are social, others are solitary (*Aeschna*), others gregarious (*Ephemeridae*). A large number pass their early

stages in the water, and many of the curious larvæ have undergone various peculiar adaptations to suit them to their environment. Nearly all the Neuroptera are carnivorous, anyone can verify this by watching a large Dragon-Fly darting about over a pond in summer and capturing and devouring butterflies and other insects; its larvæ and pupæ are still more bloodthirsty. A few species form traps for catching their prey (Ant Lions). Only one section, the *Thripidae*, are recorded in England as doing any damage to our crops and greenhouse plants. * The order as a whole may be considered a beneficial one, for several of its members devour large numbers of our insect pests, especially the Dolphins or Aphides. The Neuroptera appear to be found in nearly all parts of the world, the Caddis-Flies (*Trichoptera*) often being met with over the snow in the Arctic Circle. As to the age of the Neuroptera, they may be called our oldest insects, for in the rocks formed during the remote Devonian period we find fossil 'May-Flies' (although of ancient type [*Platephemera antiqua*] and many others closely related during the time of the deposition of our coal fields. A classification often adopted at the present day is to separate the Neuroptera with an incomplete metamorphosis, from those with a complete metamorphosis, the former are called *Pseudo-neuroptera* and the latter *Neuroptera-vera*. Some authors raise each to a separate order, others unite the Pseudo-neuroptera to the Orthoptera. Certainly they have strong resemblances to the latter as far as their metamorphosis goes; but on studying the fossil forms it can be seen that they are much more closely united to the Neuroptera-vera and on these palæontological grounds alone it is desirable to unite the two

* The larvæ of Caddis Flies (*Trichoptera*), I am told, do much harm in water-cress beds.

sections together in one order, which we call *Neuroptera*.

Neuroptera-vera.

This sub-order contains *Sialidae*, *Hemerobiidae* or 'Ant Lions,' the *Panorpidae* and the Caddis Flies or *Phryganidae* (*Trichoptera*). The first of these families is of little or no importance to us, as only one member, *Sialis lutarius*, is found in our islands, in any numbers. They have all large, reticulate wings, more or less projecting at the anal angle, with long antennæ and short and thick bodies. Some American species reach a large size, measuring five to six inches across the wings (*Corydalis cornuta,* etc.). Insects closely related to these are found in the Carboniferous rocks. The second family is of much more importance and contains many interesting species. The *Hemerobiidae* have always strongly deflexed wings, but unlike the Sialidæ the anal angle does not project and the body is usually slender. The 'Ant Lions' and 'Lace-Wing Flies' are members of this family. They are of great economic importance to us, as many of their larvæ live upon Aphides and clear them off the plants by thousands daily. Perhaps the most interesting are the Ant Lions, (*Myrmeleon and Palpares*) large insects which might easily be mistaken for Dragon-Flies, but they have less reticulate wings, which fold over the body, the head and eyes are smaller and they undergo a complete metamorphosis. There are no 'Ant Lions' found in England, but on the Continent they are plentiful in dry sandy places. Their larvæ are short, fat creatures, with a spatulate head and large mandibles; they dig out a tunnel-shaped pit in the sand and then bury themselves beneath the sand at its bottom, their large pincer-shaped mandibles alone being exposed. These curious larvæ are all carnivorous and this pit is formed as a trap to catch

their prey. Some unwary ant, or other small insect, approaches the edge of the pit and falls down with the loose sand, to be caught in the fierce mandibles of the larva (Fig. 49, *b*.) buried below. In this state they live for two years, they then turn to a pupa encased in a covering of silk and sand and from this, in a few weeks, the adult appears. The Common Ant Lion (*Myrmeleon formicarium*) (Fig. 49) is of

Fig. 49. The Ant Lion. (*Myrmeleon formicarium*).

a dark grey colour, with yellow spots, large transparent wings, ornamented with dark spots. Some of the exotic species are very large, the genus *Palpares*, one of which is the Dragon-Fly Ant-Lion, (*P. libelluloides*) contains some of the largest. *P. libelluloides* is found in France. It has large transparent wings blotched with brown.

The next most important insects in this family are the Golden Eyes or Lace-wing Flies (*Chrysopinae*). They are extremely delicate insects, with beautiful irridescent and transparent wings and delicate antennæ. Their small heads are furnished with rounded prominent eyes, of a beautiful golden colour. As a rule the Chrysopinæ are of a delicate green colour, and may be very often found flying lazily along in our gardens and woods. When caught they emit a most unpleasant odour, which is with difficulty removed. They lay their eggs on long petioles, upon the surface of a leaf, and they resemble more the

appearance of the sporangia of a fungus, than the eggs of an insect. The larvæ are known as 'Aphis Lions' on account of their chief article of food consisting of 'plant-lice,' which they devour very rapidly. The 'Aphis Lions' are longer and narrower than the 'Ant Lions' and much smaller, they often cover themselves with pieces of leaves and, like Pericles, with the skins of their victims. Eventually they spin a cocoon and remain in the pupal state about two weeks. The genus *Chrysopa* and *Hemerobius* are the most abundant, whilst a few mealy white species of *Coniopteryx* are found feeding in their larval state upon the Aphides on various coniferæ.

The Scorpion Flies (*Panorpidae*), have long, narrow, equally developed wings, with their mouth parts produced into a kind of trunk or proboscis. The 'Scorpion Flies' are common in damp places in most parts of Europe. Their larvæ live underground and probably live upon other insects. They are called Scorpion Flies on account of the singular forceps at the end of the long abdomen of the male. Species of the genus *Panorpa*, which is abundant in England, are generally black and brown with yellow markings, and brown or black blotches or spots on the wings. The 'Caddis-Flies', *Trichoptera*, are now generally considered Neuroptera-vera. At one time they were considered as a distinct order of insects, but there are not sufficient reasons for so separating them. The Caddis-Flies are also known as *Phryganidae* and are characterised by the possession of long, slender antennæ, an imperfectly developed mouth, with long, hairy wings, very few transverse veins and with the posterior pair of wings folded. The wings more resemble those of the Lepidoptera. The metamorphosis is complete and the curious larvæ are always aquatic in habits, living in cases formed of foreign matter, where they also pupate.

The adult Caddis-Flies, which are generally greyish brown or yellowish brown in colour, fly especially during the evenings and may often be found in numbers along the banks of streams and pools. They like rapidly flowing water, by the side of which the female deposits her eggs in a glutinous mass upon stones and aquatic plants. The Caddis-worms are very curious creatures. Their body is soft, but the head and thorax are horny. To protect their soft bodies these Caddis-worms construct tubes or 'houses' of various foreign materials. Some build them of pieces of stick, others of leaves, others of stones and one of small fresh-water shells. Inside these curious cases the larva spends its life, with only its head and thorax with the six legs protruding; these are immediately withdrawn into the tube, on the approach of danger. Inside these 'houses' the larvæ turn to nymphs, but prior to this change to the immobile nymph, the larvæ partly close the entrance to the tube, leaving only sufficient space for water to pass in, and attaches the other end of the case to some stone or water weed. The rudiments of the wings become marked out upon the pupal case, but when most advanced the nymph has more the characters of the larva than the adult. Closely related to these *Phryganidae* are the *Hydroptilidae*, small dark insects with short moniliform antennæ, and long fringes to the hind wings like some of the smaller Lepidoptera (micros). They are gregarious and fly at all times of the day near water. The larvæ of all the Trichoptera are aquatic and are therefore provided with modified respiratory apparatus, in the form of respiratory filaments at the side of the abdomen. So abundant were these Trichoptera in olden times that we find a deposit, of what is known as indusial limestone, two to three metres thick and of wide extent, in Auvergne, formed of their cases or indusiæ. The first and oldest record seems to be from

the Lower Purbecks of England, where a wing of a Trichopteron, called by Westwood, Phryganidium, was found.

Pseudo-Neuroptera.

The Pseudo-neuroptera are those that undergo an incomplete or imperfect metamorphosis. They are often united to the Orthoptera, but for the reason mentioned before, they are retained here as a sub-order of the Neuroptera.

Few insects attract more attention on a warm summer day when we are near water, than the Dragon Flies. They form a well marked group called the *Odonata*, which are characterised by their naked wings, which are not folded in repose, their very large and prominent eyes and huge jaws and their long abdomen. The Odonata or Dragon Flies are certainly some of the handsomest of our native insects. They are carnivorous in all their stages. The members of this family have the hind wings broader than the fore wings, and are of robust and powerful build. The second family of the Odonata or the *Agrionidae* have all the wings of equal width and are slender and delicate insects, with their eyes widely separate. The largest species of the former family belong to the genus *Aeschna*, *Ae-Grandis*, a reddish-brown insect with yellowish gauzy wings, is sometimes nearly four inches in expanse of wings. All the Odonata undergo an incomplete metamorphosis. The female lays her eggs upon the surface of the water, and the young larvæ when hatched at once commence swimming about and devouring all the smaller insects that come in their way. They are not very active, and yet by means of a curious modification they can catch the most agile insects. If you examine one of these larvæ in a bell-glass you will notice every now and then, that a curious pair of pincers are thrust out from beneath the head.

This curious weapon is a modification of the lower lip, which is elongated and has palps formed with a pair of pincers. It is attached beneath by a kind of hinge, allowing it to become folded underneath when not in use. The nymph is very similar to the larva and has the same curious modification of the lower lip, but in the active nymph stage small rudiments of wings are to be seen. Living entirely under water, these larvæ and pupæ have to breathe by means of gills. Their respiratory method is unique, for they breathe with their intestines, the large intestine especially being covered internally with numerous tracheæ. When the imago is about to emerge, the nymph crawls up some plant into the air, and the adult bursts its way out from a ruptured portion on the dorsal surface.

Libellula depressa is a broad flattish insect, yellow in the female and blue in the male; the wings expand nearly 2½ inches, and *L. quadrimaculata*, a more slender, yellow species, with two dark spots in the centre of each fore wing, may be taken as common examples of the family *Libellulidae*, with the *Aeschna grandis* mentioned before. The Agrionidæ are typically seen in the Demoiselle (*Calepteryx virgo*), with deep blue metallic wings in the male and metallic green in the female, flying lazily along our lanes in the bright sunshine.

The *Ephemeridae* or 'May Flies', also called 'Day Flies' and 'Drakes', can readily be distinguished if not already known, by the large development and net-like appearance of the anterior wings, the posterior ones being very small, sometimes even wanting; by their rudimentary mouth and by the two or three long anal setæ. They are found in swarms flying over ponds and streams, dancing up and down in the air and blown in all directions by the wind. All the May Flies are extremely delicate insects and live but for a short time in their adult state. The larvæ and

pupæ are aquatic in their habits and vegetable feeders. They are very similar in appearance in all the Ephemera. The mouth is armed with strong jaws and mandibles, and for respiration 'gills' or 'branchiæ', formed of folds of tissue with tracheæ running between them, are present on the sides of the body. The six legs are hairy, and the three or two anal filaments are present as in the adult. The nymph stage is reached after about three years of larval life. The nymph being distinguished by the rudiments of wings. When fully formed, the nymph crawls out of the water and the skin bursts along the dorsal surface and the May Fly appears, not as a fully formed imago but as a pseud-imago. When first hatched into this pseud-imago state, the May Fly is covered with a delicate membrane, this membrane is cast off and the true imago appears.

The perfect insects only live one day; they take no nourishment, their short life is only spent in love-making; then they lay their eggs in packets on the water and die after sunset.

The most interesting Neuroptera are the next family, the White Ants or *Termitidae*. In many respects the Termites resemble ants, but in reality they are quite distinct. They are social insects, the males and females having four large wings of equal size, but the workers and soldiers are wingless. The mandibles are well developed, especially in the modified 'soldiers'. The metamorphosis is incomplete, the young larvæ being like the adults in general appearance. Each species of Termite consists of several distinct castes, as the Queen, King, Worker and Soldier, each having their special duties to perform (Fig. 50). These organised communities inhabit structures known as 'Termitaria', which are huge hillocks, made of earth, stuck together with a glutinous saliva and made as hard as stone, sometimes

reaching six feet in height. There is no visible entrance to these hillocks or nests, the entrance being some way off, connected with the central building by covered galleries. These galleries run for miles beneath the soil; it is stated that nearly a third of the flat country of Ceylon is undermined by these insects.

Inside, each hillock is composed of a number of chambers and irregular intercommunicating galleries, the king and queen having large cells in the very centre. The workers are not sterile females, as in the ants, but modified *larvae*, arrested in their development; the same applies to the 'soldiers', which are modified larvæ with enormous jaws.

M. Lespes also found in *Termes lucifugum* two kinds of nymphs, some very small with rudiments of wings, others large with large wings and also two kinds of males and females, one small and appearing in May and the other large and not appearing until August. Fritz Muller also found two kinds of males and females, the wingless small ones, called by him complimentary males and females, never leaving the nests, and may possibly be of use when a royal couple is not forthcoming. At the beginning of the rainy season a number of winged males and females are produced, which when mature leave the nest and fly away. They then shed their wings and pair, and become the king and queen of future colonies. Here again we observe a difference from the true Ants, where the males perish after copulation. The workers and soldiers are always distinct from the minute they leave the egg, both are wingless and differ in the armature of the head only. The workers look after the nests and galleries and guard the royal couple. The 'soldiers' are simply for the defence of the colony. They can inflict nasty wounds with their large mandibles.

The Termite female (Fig. 50,*g*) when pregnant becomes

swollen into an immense sac, sometimes three inches long and lays as many as 60,000 eggs. These White Ants are chiefly found in the tropics, but some have spread to Europe. They do much damage to buildings; wood and all other materials, except metals, are devoured by them and houses in this way are often destroyed, their presence in the galleries in the wood not being detected

Fig. 50. Termites or White Ants, *w*. Workers, *k*. Male, *q*. Queen, *s*. Soldier.

until too late to save a general collapse of the structure which it forms. There is no doubt that the Termites, as Drummond says, do much good to the soil, acting in the same way as do the earth-worms. No Termites are found in our country.

The Thripidae or Black Fly.

The Thrips or 'Bladder-foot' of the Germans is known to all gardeners, as a destructive insect, in the greenhouse as well as out of doors. The farmer also has reasons to complain of these insects, for one species often does much damage to the cereal crops. The Thrips, also known as 'Thunder' and 'Black Flies' were at one time considered to have sufficient distinctive characters to separate them as a distinct order, under the name of *Thysanoptera*. It is still very uncertain to which order they do belong, as they have strong affinities to the Hemiptera, as well as to the Neuroptera and Orthoptera. The Thrips undergo an incomplete metamorphosis, the larva being like the adult, with the exception of the absence of wings and certain peculiarities of colour. The adults which are nearly always black, have long, narrow, equal, veinless wings, fringed on each side with long hair and laid horizontally along the back when at rest. They fly about in large numbers and get into the eyes and faces of travellers and cause great irritation. They attack the flower and leaves of plants and suck out the juices, often causing much loss. The Corn Thrip (*T. cerealium*) is one of the worst pests, it attacks the young florets and developing grain and causes light and shrivelled samples. The larvæ which resemble the black imago in general appearance, are orange coloured. The pupal stage being pale yellow and active. They appear all the summer and throughout the whole year in conservatories. There are several abundant species.

A thorough drenching with water is one of the best remedies for attack in greenhouses, but when it is a very bad attack, dipping the plants into a boiled concoction of white hellebore, (about 8 ounces of powder to 8

gallons of water) is a certain remedy. In the field we can do little to keep down this pest. It is often present in great numbers on badly drained land, and it has been found that on re-draining they disappear. They also love the shelter of high hedges, and therefore the keeping low of the latter will tend to lessen their presence. When they have been very destructive, it is well to treat the land with gas-lime, after the crop is taken, and to destroy all the grassy headlands, for they hibernate and breed amongst the grasses in the latter.

Bird-Lice (Mallophaga).

The Bird-lice were also formerly regarded as a distinct order, and were united with the *Pediculidae* to form the order *Anoplura*. But at the present time they are regarded either as Neuroptera or Hemiptera. The Bird-lice differ from the true lice, Pediculidæ, in being longer and more slender in form. They are all parasitic on birds and feed upon the soft parts of the feathers.

Thysanura and Collembola.

These two curious groups of primative insects are of extremely uncertain affinities. They are placed in this chapter, not as Neuroptera, but as a primative group of insects, which we are unable to give any definite systematic position. Both Thysanura and Collembola are wingless, mandibulate insects, not undergoing a metamorphosis and not parasitic. In the Thysanura we find long, many jointed antennæ and the abdomen composed of ten segments, whilst in the Collembola we get short antennæ and six segments in the abdomen only. It is still doubted by some that these two groups are insects, others say they are degraded Neuroptera or Orthoptera. Sir John Lubbock,

who is the authority on these arthropods, considers them primative forms of insects. The eyes of several of both these groups are different from those of all other adult insects. In Collembola they consist of from one to eight ocelli, arranged on each side of the head. Most of the Thysanura have compound eyes. Several of both are blind. The Thysanura are generally known as 'Spring Tails', from possessing two or three long caudal setæ. Some forms, as the *Lepismatidae*, are covered with scales, but most are hairy creatures. *Lepismae* are found amongst books, stores, and under stones and in damp places. The so-called 'Silver Fish' (*L. saccharina*) (Fig. 51) which is about $\frac{1}{3}$rd of an inch in length is a very common species amongst stones, old books and in dust between boards. It is called 'Silver Fish' on account of its curious silvery appearance and active gliding motion when disturbed. Other known forms are the *Campodeidae*, hairy creatures with two caudal appendages and the *Japygidae*, with caudal appendages modified into forceps and destitute of eyes. Both are found under damp stones. The *Collembola* are all very small, the largest only reaching $\frac{1}{4}$th of an inch and many described by Sir John Lubbock are only $\frac{1}{33}$rd of an inch in length. Many are gaily coloured with green and yellow, especially in the family *Smynthuridae* of Lubbock. The *Poduridae* are perhaps the most typical; they are hairy and cylindrical in form, the antennæ being few jointed and short. These Collembola are also called 'Spring Tails', on account of their possessing sal-

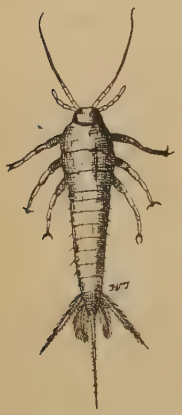


Fig. 51. *Lepisma saccharina.*

tatory appendages on the last abdominal segment but one. These appendages consist of a long forked process, which is generally bent along the under side of the body and kept there by a small catch. On releasing this, the insect is thrown into the air.

As to the true affinities of these two groups it is impossible to arrive at any definite conclusion. Sir John Lubbock considers *Campodea*, a modern representative of an ancient type-form and from which the higher insects originally took their rise.

APPENDIX I

INSECTICIDES

Object of destroying Insects—Paraffin—Quassia—Soft-soap Washes—London Purple and Paris Green—Gas-lime—Sulphur and Tobacco—Soot—Special Mixtures—Painting trees—Instruments.

At certain times insects appear in greater abundance than usual, and when this excess of any one species happens to be an insect that feeds upon cultivated plants, much damage and loss of money is often the result. If left alone the abnormal increase would gradually lessen through natural agencies, such as parasitism and inclement weather. These two natural agencies are sometimes slow working the desired results, and then we can apply with advantage methods of our own for the destruction of these insect pests. The old saying 'prevention is better than cure' applies to this subject admirably. It is far more successful to keep down an excess of insect life by clean farming, and by destroying the insects in their larval and pupal stages or in whatever way they pass the winter, so as to prevent the recurrence of future attack, than to destroy them when working. When once a well known insect pest makes its appearance even in small numbers upon the crops, measures should be taken to destroy them at once, before they have increased sufficiently to do much harm. Hop-growers fully understand the necessity of this,

in the case of the Hop Aphis; unless they are destroyed at once they increase so rapidly that they destroy the entire plants, and many failures have resulted from putting off the washings until the bines are covered with the lice, then it is too late to do much good. The various poisons and mixtures used in keeping down and destroying insect pests are known as *insecticides*. Some insecticides are extremely simple products, but must be applied with care, others are special mixtures sold at florists and elsewhere and are of much general service to the gardener and florist, but as a rule they are not satisfactory on a large scale. One of the chief objects in destroying insects is to kill them before they have increased sufficiently to have done much damage. This is unfortunately too little thought of by agriculturalists and others, if people would only remember 'a stitch in time saves nine!' The various substances for the destruction of these pests may be applied either as a fluid or in a powder. In either case the aim of the farmer or gardener should be to apply the substance in as fine a dust or spray as possible, and not to apply it too strong. More good is done by several small dressings than one heavy one. The necessity of a fine dust or spray is readily understood when we remember how insects breathe, and the minute size of some of our worst pests; we have not only to cover up their mouths with poison, but if possible to choke up the true breathing pores or spiracles. The whole plant should be so completely covered that there is no place free from poison that the insects can lodge on. One of the most useful insecticides is *Paraffin*. This oil can be applied with advantage to such diseases as 'rust' in carrots, to 'maggoty' onions, to the blistered leaves of the mangel-wurzel, to the Thrips, and should be put in all mixtures used for painting fruit trees. Paraffin has to be applied in a fluid state and it is of the utmost

importance that the oil should be thoroughly mixed with the water. It must be constantly stirred, or else we should have the oil and water separating and coming off separately, the water doing no good, the strong oil doing harm. For ordinary garden use a wineglass full of oil to a gallon of water, well mixed, is quite sufficient, and may be applied either to the land or to the leafage. It is best when using this mineral-oil to use it in the form of an *emulsion*. This is made by mixing equal proportions of paraffin and boiling soft-soap solution well together; thoroughly churning them until a thick creamy liquid is produced. This emulsion can be kept and mixed with 16—20 times its bulk of water. For wurzel-maggot it can be used with advantage by means of the 'Strawsonizer,' which keeps the oil in a thoroughly emulsified state. When used in washes, as for painting fruit trees, it should be well mixed with water before being mixed with the lime and other ingredients. For Turnip Flea pure paraffin at the rate of $1\frac{1}{2}$ to 2 gallons per acre, put on by the 'Strawsonizer', is most effectual (F. Squire). For use in greenhouses and in mixtures on a large scale, the boiled chips of *Quassia* are very useful in destroying insect life. The Quassia chips should be boiled in water for some hours, and the liquid should then be strained off and can be bottled. Four pounds of quassia will make into about 50 gallons of liquid by adding water to it.

The chief use of quassia, however, is for mixing with soft soap, as an insecticide for Aphides. These soft-soap mixtures or washes are of the greatest advantage to hop-growers for the destruction of the 'lice', and may be used with advantage to all crops suffering from 'Plant Lice', and also for fruit trees and greenhouse plants. One of the best mixtures is found to be 4 to 6 lbs. of quassia, 5 to 7 lbs. of soft-soap to 100 gallons of water. The quassia

must be boiled separately first and then mixed with the soft-soap, which has also been boiled in sufficient water to keep it liquid. The soft-soap and quassia can then be mixed with the water, and is ready for use. As in all other insecticides these 'washes' must be applied as a very fine spray, so as to saturate the leaves and stems above and below, but not to drench them. The Aphides having a mealy skin, water and the quassia alone would run off them, as water does off a duck's back, but the soft-soap fixes the poison to them and chokes up the whole surface as well as fixing the poison. Some people, prefer tobacco water or 'bitter aloes' to the quassia, but the general opinion is that the latter is far the most effectual on a large scale. Soft-soap must also be used in mixtures for American Blight, Scale and Mealy bugs, as all three have the same water repelling skins as the closely related Aphides.

To the Americans we owe the discovery of one of our most important insecticides, namely *Paris Green* and the closely related *London Purple*. Both these insect destroyers are highly poisonous, containing a large amount of arsenic, and therefore they have to be used with some care; with ordinary precaution there is not the least fear of danger from their use. They are both certain poisons for caterpillars, and are used to a large extent in America, and recently in our own country, to destroy caterpillars on fruit trees, especially those of the Winter Moth. Paris Green is a brilliant emerald green powder whilst London Purple is of a dull purple colour, the latter being finer than the Paris Green. Although powders, they can now be obtained in a moist solid form and in packets of any weight, so that there is no unnecessary handling when mixing. Both are applied to the trees in a liquid form, by means of a garden engine or some special appliance.

The following are the points to be remembered in using these two substances:—

1. Always keep the liquid *well stirred*, as both insecticides are *insoluble*, otherwise the poisons will sink to the bottom, water will come off first and do no good, then all the poison, which will do harm. The admixture of a small quantity of lime is most beneficial.
2. Apply as a *fine spray*, so as to saturate the twigs and leafage above and below, but not drench it; as soon as the leaves begin to drip, spraying should cease.
3. Two or three slight applications are more beneficial than one drenching; several days should elapse between each washing.
4. Care should be taken to use the right proportion of the poison, too little is better than too much: the following are the ordinary proportions:—
   1 lb. of poison to 400 gallons of water for peach trees;
   1 lb. „ „ „ 150-200 „ „ „ „ plum „
   1 lb. „ „ „ 150 „ „ „ „ apple „
   for currant bushes when leafage is hard the same as for plum trees can be used.
5. The trees should *not be sprayed* when the *fruit is well formed*, or even when formed at all in currant and gooseberry bushes, as the fruit would retain the arsenic and might be eaten green, and so give rise to illness.
6. Vessels in which the mixture has been kept, should be thoroughly cleansed.
7. Animals should not be allowed under the trees after spraying, as the poison drops on to the grass and would have bad effects.
8. Care must be taken when mixing the powder, to get on the windward side, so as not to *inhale the poisonous dust*, and care should be taken that none enters cuts

or sores on the hands. The use of the solid form is strongly recommended.

9. The trees should never be sprayed when in bloom, as it damages the blossom and kills the bees.
10. Trees should never be sprayed when the sun is out.
11. Two dressings are best given; one when the buds burst and another when the blossom has fallen.

As to which of the two is the better, Paris Green or London Purple, there is some difference of opinion. London Purple has several advantages over its rival; it is a finer powder and therefore more easily held in suspension in the water, it is somewhat cheaper and, I find, is less liable to burn the foliage than Paris Green.

Gas-lime, the residue from gas works, is one of the best purifiers of the land we can get. It destroys not only insect pests, but weeds as well, and where it can be obtained from gas works can be used with advantage on nearly all soils. It should be put in heaps on the land and exposed to the air for *at least a month*, so that certain changes may take place in it. During this exposure it becomes formed into sulphate of lime or gypsum, which is a valuable manure. The lime can then be ploughed in. As to the quantity to use, no definite rule can be laid down; the quantity necessarily depends upon the composition of the soil. Three cwt. to the acre is as a rule the least applied; whilst as much as several tons to the acre have been applied with advantage in certain red soils.

Sulphur may be used in various mixtures, and for dusting over plants affected with larvæ, 'flower of sulphur' being the best form. For 'thrips', burning sulphur or tobacco is found to be an excellent remedy, also for 'red spider' and other pests.

Soot is a valuable and cheap insecticide and fertilizer combined. It should be spread over the land as a dust.

The object is to get it as evenly distributed as possible, which can only be done with some machine, such as the 'Strawsonizer'; if thrown 'broad cast' with the hand, it usually falls in lumps and patches and does not do nearly so much good. It may be applied with advantage to the leafage when wet, so that it clings to them as well as to the soil. Powdered lime mixed with it forms also a good insecticide.

There are a large number of '*special mixtures*' sold for the destruction of insect pests, most of which are of some use and many are valuable aids to the gardener for use in conservatories. These special mixtures which can be got from all florists, are, however, of little use in the field.

For the destruction of 'scale', 'American Blight', etc., on trees, *painting* is most effectual. Painting the trunks should be done in the late autumn and early spring. It is most essential before applying the 'paint', to scrape the rough bark off the trunk, so as to get as smooth a surface as possible. The mixture should be well rubbed into every crack and crevice with a hard brush. The following are good mixtures for painting:—

(1) ½ peck of quick lime
½ lb. flower of sulphur
¼ lb. lamp black
Boiling water.
} applied to the stem warm.

(2) 1 lb. soft-soap
½ lb. flower of sulphur
½ pint of paraffin or petroleum
½ peck of lime.

(3) Whitewash
Size
Paraffin.

For 'scale', a thorough scrubbing with soft-soap and then painting with ordinary whitewash and size thickly, is most effectual, and also the use of paraffin and kerosene emulsions. Resin washes are, however, most advantageous.

Bisulphide of Carbon is largely used abroad as an insecticide for underground pests, and is most successful. It can be placed under the soil in small glass tubes, open at one end, or in small gelatinous capsules.

Special instruments are now manufactured for spreading insecticides, which are of great importance, as this cannot be well done by hand or by an ordinary garden engine. The chief object is to get both the dry and fluid dressings in as fine a state as possible.

The 'Strawsonizer', which is drawn by one horse, is one

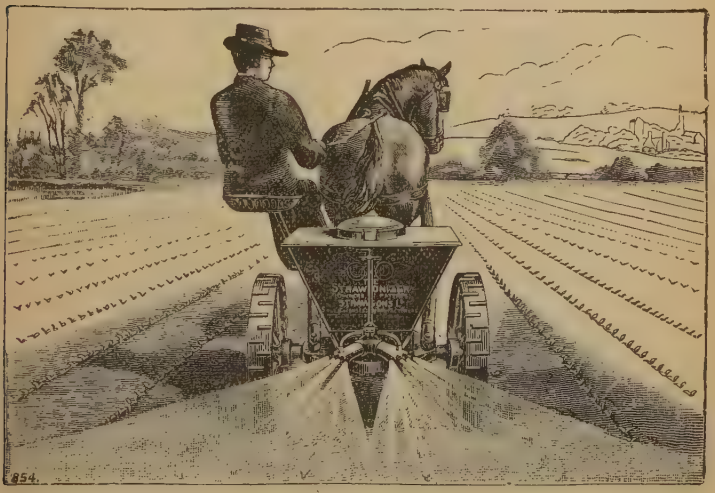


Fig. 52. Strawsonizer.

of the most useful instruments in checking insect pests. It can be taken over large areas of ground rapidly, and

spreads the powder or liquid in a fine mist, sending it with force upon the ground, and so causing the application to rebound and become attached to the lower surface of the leafage as well as the upper. They are made now for either dry or liquid dressings and are especially well adapted for the latter, as the fans inside, which force out the fluid, keep at the same time the solution, thoroughly mixed. For garden use, fruit trees, etc., an ordinary garden engine, with a fine nozzle attached, may be used. Two of the best nozzles are the 'Vermorel' and 'Rileys'; these send the fluid in a finely divided spray or mist over

Fig. 53. Eclair Knapsack Pump.

the trees. The best apparatus for spraying fruit trees is the 'Eclair' Knapsack No. 1, which is carried on a man's

back; the man holding the tube and nozzle in one hand and pumping out the liquid with the other. It may be obtained from Messrs. Clark & Co., Windson Chambers, Great St. Helen's, E.C. This Knapsack Pump has also special advantages, in keeping the mixture in constant agitation. Strawson's 'Notus' Knapsack is also most useful and effectual. Hop-washing machines were usually worked by hand, but all the larger planters now use them drawn by horses, and thus get over 4 to 5 acres per day. By the horse machines the washes are forced by strong pumps set in action by the wheels, through a series of tubes arranged on each side of the machine, having perforations at regular intervals, serving as nozzles. The 'Strawsonizer' has been adapted for hop-washing and has been found most successful.

Certain *artificial manures* are of much benefit in destroying grubs under the soil, *nitrate of soda* and *kainit* are both very obnoxious to insects, such as Wire-worm, Leather Jackets and Surface-Larvæ. Superphosphates, I find, on the other hand, have no effect upon these subterranean forms.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APPENDIX II

List of more important Works and Monographs on Special Groups of Insects.

GENERAL SUBJECTS.

1. Embryology of Insects. BALFOUR'S Comparative Embryology.
2. Senses of Insects. LUBBOCK.
3. Insect Variety, its Propagation and Distribution. A. H. SWINTON. *London & New York.*
4. Distribution and Correlation of Fossil Insects. P. B. BRODIE.
5. On the Origin and Metamorphoses of Insects. SIR J. LUBBOCK.
6. Fossil Insects of North America, with notes on European Species. S. H. SCUDDER. 2 vols. *New York,* 1890.
7. Melanism in British Lepidoptera. J. W. TUTT, 1891.
8. Anatomy, Morphology and Physiology of Blow-Fly. LOWNE *London,* 1890—92.

COLEOPTERA.

9. Revision der Europäischen *Otiorhynchus* Arten. STIERLIN. *Berlin,* 1861.
10. Handbook of the Coleoptera of Great Britain and Ireland. H. E. COX. 2 vols. 1874.
11. Geodephaga Britannica. A Monograph of Carnivorous Ground Beetles. J. F. DAWSON. 1854.
12. Monograph of *Halticidæ* in Collection of British Museum. CLARK. 1860.
13. Coleoptera of British Isles. A descriptive account of the families, genera and species indigenous to Great Britain and Ireland. W. W. FOWLER. 5 vols. 1887—91.

14. Monographie des Cicindelides. J. THOMSON. *Paris*, 1857.
15. Monographie des Elatérides. E. CANDÈZE. 4 vols. *Liége*, 1857–63.

HYMENOPTERA.

16. Species des Hyménoptères d'Europe et d'Algérie. ED. ANDRÉ. *Beaune*, 1879.
17. A Monograph of British Phytophagous Hymenoptera. P. CAMERON. (Ray Society) 3 vols. 1882—90.
18. Hymenoptera Britannica. *Oxyura* and *Alysia*. A. H. HALIDAY. *London*, 1839.
19. Ants, Bees and Wasps, a record of observations on the habits of Social Hymenoptera. LUBBOCK. 1882.
20. Monograph of British *Braconidæ*. T. A. MARSHALL. (Trans. Ent. Society.) *London*, 1885—89.
21. Catalogue of British Hymenoptera; *Chrysididæ*, *Ichneumonidæ*, *Evanidæ* and *Braconidæ* and *Oxyura*. T. A. MARSHALL. (Publ. Ent. Society.) *London*, 1872—3.
22. Synopsis of British Heterogyna and Fossorial Hymenoptera (I). E. SAUNDERS. *London*, 1880.
23. Synopsis of British Diploptera and Anthophila. (II). E. SAUNDERS. 1882—84.

LEPIDOPTERA.

24. Larvæ of British Butterflies and Moths. W. BUCKLER. Edited by Stainton (Ray Society). *London*, 1886—94.
25. European Butterflies and Moths. KIRBY. 1882.
26. A Manual of British Butterflies and Moths. STAINTON. 2 vols. *London*, 1857—59.
27. Insecta Britannica. Lepidoptera. *Tineina*. STAINTON. 1854.
28. A Catalogue of British *Tineidæ* and *Pterophoridæ*. STAINTON. *London*, 1849.
29. British Tortrices. S. J. WILKINSON. *London*, 1859.
30. British Noctuae and their Varieties. J. W. TUTT. *London*, 1891—92.
31. Die Raupen der Gross-Schmetterlinge Europas. DR. E. HOFMANN.
32. Die Gross-Schmetterlinge Europas. PROF. E. HOFMANN. *Stuttgart*, 1894.

DIPTERA.

33. Fauna Austriaca. Die Fliegen. J. R. SCHINER. 2 vols. *Wien*. 1862—64.

34. An Account of British Flies. (*Pulicidae to Chironomidae*). Vol. I. F. V. THEOBALD. *London*, 1892.
35. A List of British Diptera. G. H. VERRALL. *London*, 1888.
36. Insecta Britannica. Diptera. F. WALKER. 3 vols. *London*, 1851—53.
37. Monographie der Oestriden. F. BRAUER. *Wien*, 1863.

HEMIPTERA.

38. Monograph of British Aphides. G. B. BUCKTON. 4 vols. (Ray Society.) *London*, 1876—83.
39. Monograph of British Cicadae or Tettigidae. G. B. BUCKTON. 2 vols. *London*, 1890—91.
40. British Hemiptera. Vol I. Hem. Heteroptera. DOUGLAS & SCOTT. (Ray Society), 1865.
41. Synopsis of British Hemiptera—heteroptera. E. SAUNDERS. *London*, 1892.
42. Monographia Anoplurorum Britanniae, or an Essay on the British species of Parasitic Anoplura. HENRY DENNY. *Norwich*, 1825.

ORTHOPTERA.

43. Prodromus der europäischen Orthopteren. CARL BRUNNER VON WATTENWYL. *Leipzig*, 1882.
44. Orthoptera Europaea. L. H. FISHER. *Lipsiae, Parisiis, Londini*, 1853.
45. Synopsis of the Species of Insects belonging to the Family of *Phasmidae*. G. R. GRAY. *London*, 1835.
46. Catalogue of the *Dermaptera saltatoria* and supplement to the *Blattariae* in the British Museum. F. WALKER. Parts I—V. *London*, 1869—71.

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47. A Monograph of the *Ephemeridae*. A. E. EATON. (Trans. Ent. Society.) *London*, 1871.
48. British *Libellulinae* or Dragon Flies. W. F. EVANS. *London*, 1845.
49. Monographie des Libellulidées d'Europe. BARON SELYS-LONGCHAMPS. *Paris*, 1840.
50. Monograph of the British Species of *Chrysopa*. W. F. EVANS. (Trans. Ent. Society.) *London*, 1848.
51. Monographie Libellulinarum Europaearum specimen. P. L. VAN DER LINDEN. *Bruxelles*, 1825.

52. Catalogue of British Neuroptera. McLACHLAN. (Publ. by Ent. Society.) *London*, 1870.
53. Monographic Revision and Synopsis of the *Trichopterœ* of the European Fauna. McLACHLAN. Text and plates. 2 vols. *London*, 1874—80.
54. Monograph of British *Neuroptera—Planipenna*. McLACHLAN. *London*, 1868.

THYSANURA and COLLEMBOLA.

55. Monograph of *Collembola* and *Thysanura*. SIR J. LUBBOCK. (Ray Society.) *London*, 1893.

ECONOMIC ENTOMOLOGY.

56. Farm Insects. J. CURTIS. *Edinburgh*, 1860.
57. Insects Injurious to Fruits. W. W. SAUNDERS. 1884.
58. Practische Insekten-kunde oder Naturgeschichte aller derjenigen Insekten. E. L. TASCHENBERG. 5 vols. *Bremen*, 1879—80.
59. Economic Entomology. Aptera. ANDREW MURRAY. *London*, 1877.

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INDEX

A.

Abdomen, the, 28.
Abraxas grossulariata, 123.
Acanthocinus Aedilis, 72.
Aceta domestica, 196.
Acetidae, 196.
Active pupae, 17.
Adephaga, 48.
Aëpophidus, 189.
Aepus, 51, 189.
Aeschna, 299, 205.
Agrionidae, 205, 206.
Agriotes lineatus, 61.
Agrotis, 117.
Aleyrodidae, 183.
Alimentary canal, 21, 38.
Alucitae, 140.
American Blight, 181.
Andrenae, 96.
Anobium tessellatum, 64.
Anoplura, 175, 189, 211.
Anopthalmus, 51.
Antennae, 29.
„ structure of, 30.
Anthocoris nemorum, 187.
Anthomyia brassicae, 167.
„ floralis, 167.
„ radicum, 167.
Anthomyidae, 167.
Anthonomus pomorum, 69.
Anthophila, 95.
Anthophora, 97.
Ant Lions, 202.
Ants, 89.
Apathi, 99.
Aphaenops, 51.
Aphaniptera, 145.
Aphidae, 178.
Aphis Lions, 203.
Aphis rumicis, 181.
Apion apricans, 69.
Apis mellifica, 99.
Apollo-butterfly, 110.
Apple-blossom Weevil, 69.
Arachnida, 2, 3.
Argynnis, 106.
Aromia moschata, 72.
Arthropods, classification of, 2.
Asilidae, 158.
Asopia farinalis, 129.
Astemma aptera, 187.
Athalia spinarum, 83.
Athous hæmorrodalis, 61.
Auditory organs, 31.

B.

Bean Aphis, 181.
Bean Weevils, 67.
Bees, 95.
Bibionidae, 156.
Bird Butterflies, 110.
Bird Lice, 211.
Blaberus giganteus, 194.
Black Flies, 210.
Blaps, 65.
Blatta americana, 194.
„ orientalis, 194.
Blattidae, 190, 193.
Blissus leucopterus, 187.
Blow-fly, 142.

Blue-bottle-flies, 166.
Body-louse, 190.
Bombi, 98.
Bombyces, 111.
Bombycidae, 142.
Borboridae, 142.
Bots, 144.
Botys, 130.
Brachinus, 51.
Braconidae, 87.
Brachycera, 145, 158.
Brachyelytra, 54.
Braulidae, 173.
Breeze Flies, 160.
Bruchidae, 67, 70.
Bugs, 174.
Burying Beetles, 56.

C.

Cabbage-butterflies, 101, 108.
Cabbage-flies, 167.
Caddis-flies, 112, 200, 203.
Calandra granaria, 69.
Calliphora, 166.
Calocoris fulvomaculatus, 187.
Calopteryx virgo, 206.
Calosoma sycophanta, 50.
Campodeidae, 212.
Cantharidae, 65.
Carabidae, 48, 49.
Carabus, 50.
Carabus auratus, 50.
„ catenulatus, 50.
„ nitens, 80.
„ violaceus, 50.
Carpocapsa pomonella, 131.
„ splendana, 132.
Carrot-blossom Moth, 136.
Carrot-fly, 169.
Caterpillars, 11, 101.
Cecidomyidae, 86, 143, 148.
Cecidomyia destructor, 148, 151.
Celery-fly, 169.
Cephinae, 82.
Cephus pygmaeus, 82.
Ceratitis hispanica, 170.
Cercopidae, 176.
Cerura vinula, 113.
Cetoniinae, 58, 60.
Ceutorhynchus sulsicollis, 69.
Chalcididae, 87.
Chinch-bug, 187.
Chironomidae, 144, 153.
Chironomus, 144.
Chlorops taeniopus, 171.
Chrysididae, 80.
Chrysomelidae, 73.
Chrysopinae, 202.
Chrysops, 160.
Cicadae, 174.
Cicadidae, 176.
Cicindela campestris, 48.
Cicindelidae, 48.
Cimbicinae, 81.
Cimicidae, 187.
Cimex lectularius, 184, 187.
Cis boleti, 64.
Classification, 5.
Clavicornia, 55.
Click-beetles, 60.
Clothes-moths, 135.
Clouded-yellow, 109.
Clyti, 72.
Cnethocampa processionea, 50.
Coccinellidae, 76.
Coccidae, 183.
Coccuscacti, 185.
„ marinipurensis, 186.
Cochineal-insects, 174, 176, 183.
Cockchafer, 59.
Cockroaches, 192.
Codlin-moth, 131.
Coleophora, 135.
Coleoptera, 5, 46, 77.
Colias edusa, 110.
Collembola, 211.
Collier, 181.
Coloration, 104.
Colorado Beetle, 73.
Complete metamorphosis, 17.
Conops, 144.
Conorrhinus Renggeri, 188.
Corethra plumicornis, 19.
Corn Aphis, 181.
Corn Sawfly, 82.
Corn Weevil, 69.
Corydalis cornuta, 201.
Cossus ligniperda, 134.
Crab Louse, 190.
Crambi, 130.
Crickets, 196.
Crustacea, 2, 3.
Cuckoo Bees, 97.
„ Spit, 177.
Culicidae, 67.

Cuculio nucum, 69.
Culicidae, 144, 145, 153.
Cursoria, 190.
Currant Moth, 123.
Currant Sawfly, 84.
Cyclorrhapha, 161.
Cynipidae, 80, 86.

D.

Daddy-long-legs, 154.
Daninae, 105.
Dart Moth, 117.
Death-watch, 64.
Death's-head Moth, 111.
Deinacridae, 196.
Demoiselle, the, 206.
Depressaria, 136.
Dermestidae, 57.
Dermestes lardarius, 57.
,, vulpinus, 58.
Diamond-back Moth, 134, 138.
Digestion, 40.
Dilophus febrilis, 156.
Diploptera, 93.
Diplosis botularia, 149.
,, pyrivora (nigra), 150.
,, tritici, 148, 150.
Diptera, 6, 141.
Diurnal Lepidoptera, 105.
Dolphins, 178.
Dragon-flies, 205.
Dytiscidae, 52.
Dytiscus marginalis, 52.

E.

Earwigs, 192.
Elateridae, 61.
Embryonic development, 8.
Emergence, of insect, 23.
Ephemeridae, 199, 206.
Eproboscidae, 172.
Eristalidae, 144, 162.
Eristalis tenax, 162.
Euacanthus interruptus, 177.
Eumenidae, 93.
Euplexoptera, 192.
Eupoda, 72.
Evanidae, 87.
External anatomy, 25.
Eyes, 32.
Eyes, compound, 32.
Eyes, simple, 34.

F.

Fever-fly, 157.
Fire-flies, 60, 64.
Flat-bodied-moths, 136.
Flax-seeds, 150.
Forest-fly, 172.
Forficula auricularia, 193.
Forficulidae, 192.
Formicidae, 89.
Fossil May-flies, 200.
Fossil trichoptera, 202.
Fossorial-hymenoptera, 93.
Fritillaries, 106.
Frog-hoppers, 176.
Fulgoridae, 175, 176.

G.

Gad-fly, 142, 189.
Galeriidae, 130.
Gall-flies, 80, 86.
Gall-gnats, 148.
Garden-Pebble-moth, 130.
Gas-lime, 216.
Gastrophilus equi, 165.
Gelechia, 135.
Generative System, 45.
Geodephaga, 48.
Geometrae, 121.
Gerridae, 188.
Gipsy-moth, 112.
Glossina norsitans, 166.
Glow-worm, 63.
Goat-moth, 134.
Golden-eye fly, 202.
Gooseberry-sawfly, 84.
Gout-fly, 171.
Grasshoppers, 192, 196.
Grass-moths, 130.
Great Water-beetle, 52.
Gressoria, 192, 194.
Grub, 11.
Gryllidae, 196.
Gryllotalpa vulgaris, 196.
Gyrinidae, 52.
Gyrinus natator, 53.

H.

Halictus, 97.
Haltere, 142.
Haltica concinna, 74.
„ nemorum, 74.
„ undulata, 74.
Halticidae, 74.
Harmless Water-beetle, 53.
Hawk-moths, 111.
Head, the, 26.
Head-Louse, 190.
Heart, the, 44.
Hemerobiidae, 201.
Hemiptera, 6, 173.
Hepatic-canals, 39.
Hesperidae, 110.
Hessian-fly, 148, 151.
Heterocera, 104, 110.
Heteromera, 47, 65.
Heterometabolic insects, 19.
Heteroptera, 6, 174, 184.
Hippoboscidae, 172.
Histolysis, 21, 22.
Holometabolic insects, 19.
Homoptera, 6, 174.
Honey-Dew, 178.
Hop Aphis, 179.
Hop Flea, 74.
Hop Frog-fly, 177.
Horse Bot, 164.
House Cricket, 196.
House-fly, 166.
Hover-flies, 161.
Hydradephaga, 48, 51.
Hydrocampidae, 129.
Hydrophilidae, 53.
Hydrophilus piceus, 53.
Hylobates, 188.
Hylotominae, 81.
Hymenoptera, 6, 78.
Hymenoptera-aculeata, 89.
Hymenoptera-terebrantia, 80.
Hystrichopsylla, 148.
Hypoderma bovis, 163.
Humble-bees, 98.

I.

Ichneumonidae, 80, 87.
Ichneumon-flies, 80, 87.
Imaginal-discs, 19.
Incomplete metamorphosis, 18.
Insecta, 2, 4.
Insecticides, 214.
Internal Anatomy, 38.

J.

Japygidae, 222.
Jigger, the, 148.

K.

Knot-horn Moths, 130.

L.

Lace-wing fly, 202.
Lackey-moths, 115.
Lady-birds, 76.
Lamellicornia, 58.
Lampyris splendidula, 61.
Lantern-flies, 174.
Lasiocampidae, 115.
Larvae, 11, 101.
Leaf-cutting bees, 98.
Leaf-insects, 195.
Leather-jackets, 155.
Legs, 37.
Lepidoptera, 6, 100.
Lepismatidae, 212.
Leucanidae, 120.
Lewoniidae, 106.
Libellulidae, 206.
Liparidae, 112.
Locusts, 196.
Locustidae, 196.
London Purple, 217.
Longicornia, 71.
'Loopers', 121.
Lopaphus cocophages, 195.
Lophysinae, 82.
Lophyrus pini, 85.
Lucanidae, 58.
Lydinae, 82.
Lygeidae, 186.

M.

Maggots, 11.
Maggoty Peas, 132.
Magpie Moth, 123.
Malacodermata, 63.
Mallophaga, 211.
Malpighian, tubules, 39.

Mantidae, 194.
May Flies, 206.
Meal Moth, 129.
Meal Worm, 65.
Megachile, 98.
Melalontha vulgaris, 59.
Melalonthidae, 58.
Meligethes aeneus, 58.
Melophagus ovinus, 178.
Mercurial ointment, 165.
Metamorphoses, 8.
Mole Cricket, 196.
Moths, 111.
Moulting, 12.
Mouth, the, 35.
Mullein Moth, 121.
Musca, 142.
Musca domestica, 166.
Muscidae, 166.
Musk-beetle, 71.
Mussel Scale, 184.
Mustard-blossom Weevil, 58.
Mutillidae, 93.
Mycetophilidae, 145.
Myriapoda, 2.
Myrmeleon, 202.
Mytilaspis pomorun, 184.

N.

Necrophaga, 55.
Necrophorus, 56.
Needle-nosed Hop-bug, 187.
Nematus ribesii, 84.
Nematocera, 145.
Nepidae, 189.
Nepticulidae, 135.
Neuroptera, 7, 28, 199.
Neuroptera-vera, 201.
Nervous system, 21, 40.
'Niggers', 83.
Nitidulidae, 58.
Noctuae, 116.
Nomada, 97.
Notodontidae, 113.
Nut Weevil, 69.
Nycteribidae, 173.
Nymphalidae, 105.

O.

Ocypus olens, 55.
Odonata, 205.
Odynerus, 93.
Oestridae, 142, 144, 162.
Oestrus 13, 164.
Oestrus ovis, 165.
Onion-fly, 168.
Orange-fly, 170.
Ornithoptera, 110.
Orthoptera, 6, 191.
Orthorrhapha, 145.
Otiorhynchus sulcatus, 69.
,, picipes, 69.
Ox Warble, 163.

P.

'Palmers', 83.
Palpares, 201.
Palpicornia, 53.
Panorpidae, 203.
Papilionidae, 107, 110.
Paraffin, 215.
Paris Green, 215.
Parthenogenesis, 180.
Pea Moths, 133.
Pearl Moths, 130.
Pea Weevils, 67.
Pediculidae, 175, 189, 211.
Pediculus capitis, 190.
,, vestimenti, 190.
Pentamera, 47.
Pentatoma grisea, 186.
Phasmidae, 194.
Phibalocera pythonius, 195.
Phorbia cepetorum, 168.
Phorodon humuli, 179.
Phryganidae, 201.
Phthirius inguinalis, 190.
Phycidae, 130.
Phyllium, 195.
Phylloxera Vastatrix, 182.
Pieridae, 101, 108.
Pieris brassicae, 108.
Pine-bud Tortrix, 133.
Pine-sawfly, 85.
Pionea forficalis, 130.
Plant Lice, 174, 178.
Plusidae, 120.
Plutella cruciferarum, 134, 138.
Poduridae, 28, 212.
Post-embryonic development, 11.
Praying Insects, 194.
Prionidae, 71.
Proboscidea, 161.
Procephalic lobes, 10.

Pselaphidae, 55.
Pseudo-neuroptera, 7, 199, 205.
Pseudo-trimera, 76.
Psila rosae, 169.
Psychidae, 112.
Pterophori, 140.
Pulex, 142.
„ gallinae, 147.
„ irritans, 148.
Pulicidae, 7, 145.
Pulvinaria ribesiae, 182.
Pupae, 103.
Puparia, 145.
Pupal stage, 14.
Pyrales, 129.

Q.

Quassia, 214.
Quiescent-pupae, 16.

R.

Raspberry Weevils, 69.
Rat-tailed larvae, 144, 162.
'Red-gum', 148, 150.
'Red-maggot', 148.
Reduviidae, 188.
Reduvius personatus, 188.
Respiratory System, 42.
Retinia, 133.
Rhammatocerus, 198.
Rhopalocera, 104, 105.
Rhopalosiphum dianthi, 181.
Rhynchophora, 66.
Robber-Flies, 158.
Ruby-tailed Flies, 80.

S.

Salivery Glands, 38.
Saltatoria, 192, 196.
Sand Wasps, 93.
Sarcophagidae, 144.
Sarcopsylla penetrans, 148.
Saturniidae, 114.
Satyrinae, 105.
Sawflies, 80.
Scale Insects, 174, 183.
Scales, of Lepidoptera, 104.
Scarabaeinae, 59.
Schizoneura lanigera, 181.
Scolytus, 70.
Scorpion Flies, 203.
Scutellaridae, 186.
Sheep-nasal Bot, 165.
Sheep Tick, 173.
Shield Bugs, 186.
Sialidae, 201.
Sialis lutarius, 201.
Silk-moths, 114.
Silpha opaca, 57.
Silphidae, 56.
Silver-Fish, 212.
Silvery Y-Moth, 120.
Siphonophora granaria, 181.
Sirices, 80, 83.
Sitones crinitus, 67.
„ lineatus, 67.
Skin, 13.
Skippers, 110.
Smell organs, 31.
Smother-flies, 179.
Snow-flies, 182.
Solitary Ants, 92.
Soot, 217.
Spectre Butterflies, 105.
Sphegidae, 93.
Sphinges, 111.
Spiracles, 42.
Spring-Tails, 212.
Staphylinidae, 55.
Sternoxi, 60.
Stick Insects, 192.
Stigmata, 28, 42.
Stratiomyidae, 143, 159.
Stratiomys chamaeleo, 159.
Strawsonizer, 220.
Strepsiptera, 66.
Stylopidae, 66.
Stylops, 7, 66.
Sulphur, 219.
Surface-caterpillars, 117.
Swallow-tail Butterflies, 107.
Swallow-tail Moth, 122.
Syrphidae, 161.

T.

Tabanidae, 142, 159.
Tachinidae, 144.
Tenebrionidae, 65.
Tenebrio molitor, 65.
Tenthredinidae, 80.
Tephritis onorpodinis, 170.
Teredilia, 64.

Termites, 199, 207.
Tetramera, 47.
Thorax, 27.
Thripidae, 200, 210.
Thunder Flies, 210.
Thysanoptera, 210.
Thysanura, 199, 211.
'Timber-Man', 72.
Tineae, 134.
Tineae cerealium, 135.
„ crinella, 135.
„ pellionella, 135.
„ trapetzella, 135.
Tipula, 143, 144, 154.
„ maculosa, 156.
„ oleracea, 155.
Tipulidae, 143.
Tortrices, 131.
Tortrix viridiana, 131.
Tracheae, 47.
Trichoptera, 100, 199, 201.
Trimera, 47.
Trypetidae, 170.
Tsetse Fly, 166.
Turnip-flea, 74.
Turnip-sawfly, 83.
Turnip-moth, 117.
Typhlopsylla, 148.

U.

Urapterydae, 122.
Urapteryx sambucata, 122.

V.

Vanessa, 106.
Vapourer Moth, 111.
Vascular System, 44.
Veopidae, 94.
Vespa sylvestris, 94.
„ vulgaris, 94.
„ crabro, 95.
Volucella, 144, 161.
„ bombylans, 161.
„ zonaria, 161.

W.

Wainscot Moths, 120.
Warbles, 142, 162.
Wasps, 93.
Weevils, 66.
Wheat Midge, 148, 150.
White Ants, 199, 207.
White Butterflies, 107.
White Woolly Currant Scale, 184.
Wings, 36.
Winter Moths, 125.
Wire-worms, 60.
Wood-wasps, 80, 85.
Woolly Aphis, 181

X.

Xylinidae, 121.
Xylophaga, 70.

Y.

Yellow-Underwings, 119.

Z.

Zabrus gibbus, 51.
Zerenidae, 123.
Zophodia convolutella, 130.

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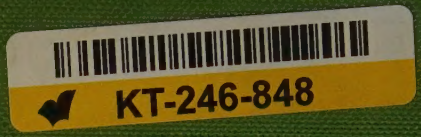
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